ATTACHMENT 3

TEST REPORT

EMISSION TESTING OF AUSTRATIAN VEHICLES

USING ETHYL® MMT ANTIKNOCK COMPOUND™

J.M. McChesney
Ethyl Petroleum Additives
St. Louis, MO
December 7, 1988

INTRODUCTION

This report details a test program where vehicles were subjected to emissions testing to Australian Design Rule 37A using unleaded fuel with and without the fuel additive "Ethyl" MMT Antiknock Compound.

The vehicles selected for testing were substantially representative of 1986 new car sales.

Australian Design Rule 37A, introduced 1st January, 1986, specified that all vehicles must operate on unleaded petrol which has a Research Octane Number between 91 and 93 maximum and 82 minimum Motor Octane Number. Exhaust emissions standards of 0.93 g /km hydrocarbons, 9.3 g/km carbon monoxide and 1.93 g/km oxides of nitrogen are also a requirement of ADR 37A.

Fuel conforming to the ADR 37A Standard Test Fuel Specification was used in this program in both clear form and treated with "Ethyl" MMT.

All tests were conducted at the New South Wales State Pollution Control Commission's Vehicle Testing Facility at Lidcombe NSW.

Based on a thorough review of the test data no significant difference in exhaust emissions was measured between the clear and "Ethyl" MMT treated fuels. The six car average emission results are:

Emission Test	Clear Fuel g/km	"Ethyl" MMT Fuel g/km	Percent Difference Test Fuel vs Clear Fuel
HC	0.265	0.255	-3.7
CO	4.985	4.983	-0.01
NOx	0.932	0.913	-2.1

TEST VEHICLE

Rental cars were used in this program which had completed at least 10000km durability to ensure that combustion chamber deposits had stabilized.

The vehicles were tuned to the manufacturers' specifications prior to testing with particular attention being paid to the effective operation of the emission control systems.

To allow easy operation on the dynamometer the fuel tanks were completely drained and sufficient quantity of the appropriate test fuel added to conduct three complete cold start tests. For each vehicle the baseline fuel was tested first for at least three tests. Where unacceptable repeatabilty was monitored additional tests were conducted.

TEST PROCEDURE

The vehicles were stored for a minimum of 12 hours and a maximum of 20 hours at an ambient temperature of 22 +/-2 deg C. Where vehicles had been stored for more than 24 hours they were started and run until normal operating temperatures had been reached.

Emission tests were conducted at the appropriate inertia test weight and power loading applicable to the individual vehicles according to the ADR 37A test procedure.

To avoid driver variations the same driver was used for each vehicle throughout the test program.

TEST COMMENTS

Holden Commodore

The average results obtained from this vehicles show small improvements in all three mandated exhaust constituents with the fuel containing "Ethyl" MMT.

Toyota Corona

Little difference was measured between the average results obtained with the clear and "Ethyl" MMT treated fuels.

Holden Gemini

Reductions in both carbon monoxide and oxides of nitrogen were recorded with the "Ethyl" MMT treated fuel when compared with the clear fuel.

Mitsubishi Magna

Increased carbon monoxide emissions were monitored with the use of fuel containing "Ethyl" MMT which encouraged a repeat test using the clear fuel. The result of this test indicated that the CO emissions had changed somewhat during the test program.

Ford Laser

After significant differences were monitored between the clear fuel and test fuel for all constituents with increases in carbon monoxide and hydrocarbons and a decrease in oxides of nitrogen levels, a further two tests were run using the clear fuel. The results from the first of these repeat tests was considered unusual and examination of the vehicle revealed a detached signal hose. This hose was reconnected and a second test conducted which showed that carbon monoxide emissions had increased to a level similar to those recorded during the "Ethyl" MMT treated fuel tests.

Following the indifferent results obtained from the first Ford Laser it was decided to conduct a further test on another vehicle. The tests were conducted using the same batch of fuel at the New South Wales State Pollution Control Commission's Vehicle Testing Facility at Lidcombe NSW.

The average results obtained from the second Ford Laser show small improvements in all three mandated exhaust constituents from the use of fuel containing "Ethyl" MMT.

Ford Falcon

The third test on the fuel containing "Ethyl" MMT produced low carbon monoxide and oxides of nitrogen levels. The laboratory expressed some doubt whether the correct dynamometer loading had been used. Consequently the result was treated as an outlier.

Discounting the aforementioned test there was little difference between the clear and MMT dosed fuel results.

Ford Fairlane

This vehicle was originally chosen because the emission control system consists of multi-point fuel injection and two way catalyst without air injection and is unique on the Australian market. Unfortunately, the first test vehicle failed to meet emission regulations. Another vehicle of the same model was obtained and prepared for test but exhaust emissions at idle and 2500 rpm were similar to the first car and it was decided not to conduct a complete emission test.

COMMENTS AND DISCUSSION

The vehicles chosen for this program represented not only the current Australian market but also the range of emission control systems being used to meet the 1986 Australian emission standards.

As mentioned earlier it was not possible to obtain an example of the Ford Falcon (i.e. the Ford Fairlane) fitted with multi-point fuel injection which conformed with emission standards. Hence, the carburetor version was substituted in its place.

CONCLUSION

(1) Within the scope of the test program no significant difference in exhaust emissions was measured between the clear and"Ethyl" MMT treated fuels.

(2) The analysis shown below demonstrates the importance of vehicle emission stability on the comparisons being made especially at the low emission rates produced by 1986 model year vehicles.

(3) Following a review of the raw data we excluded the repeat test using the clear fuel on the Mitsubishi Magna, the original Ford Laser test and the Ford Fairlane test. Based on the remaining six vehicles we calculated the following conclusion:

Emission Test	Clear Fuel g/km	"Ethyl" MMT Fuel g/km	Percent Difference Test Fuel vs Clear Fuel
HC	0.265	0.255	-3.7
CO	4.935	4.983	+1.0
NOx	0.932	0.913	-2.1

MMT TEST PROGRAM

APPENDIX 1

TEST VEHICLE SPECIFICATION

Test Vehicle No. 1

Vehicle Make & Model: Holden Commodore Reg.No.: OAX 643

Chassis No. AVL012780M Engine No. 028503A6 8K196F999396

Transmission: Auto Engine Size & Type: 3000cc In Line 6

Build Date: 6/86 Odometer: 10936 km (at start of testing)

Emission Control System: Electronic multipoint fuel injection.
3 Way Catalyst

Ignition Timing: 15 deg BTDC Idle Speed: 700 r/min

Inertia: 1590 kg

Date	Test No.	Cycle Result (g/km) HC	CO	Nox	CO2	TEST CONDITION
28/10/86	8231	0.43	4.7	0.13	281.1	ADR 37 Test Fuel
29/10/86	8235	0.38	4.5	0.12	277.1	ADR 37 Test Fuel
30/10/86	8236	0.42	4.7	0.10	279.7	ADR 37 Test Fuel
	Avg.	0.41	4.63	0.12	279.30	
	S.D.	0.03	0.12	0.02	2.03	
6/11/86	8241	0.32	3.8	0.10	271.0	ADR 37 Test Fuel+MMT
7/11/86	8246	0.41	4.8	0.11	275.8	ADR 37 Test Fuel+MMT
10/11/86	8247	0.38	4.8	0.10	285.5	ADR 37 Test Fuel+MMT
	Avg.	0.37	4.47	0.10	277.43	
	S.D.	0.05	0.58	0.01	7.39	

MMT TEST PROGRAM

APPENDIX 2

TEST VEHICLE SPECIFICATION

Test Vehicle No. 2

Vehicle Make & Model: Holden Gemini Reg. No. NZA 274

Chassis No. BRB012275A Engine No. 1327424 8C694FL202917B

Transmission: Manual 5 Speed Engine Size & Type: 1500 cc Inline 4

Build Date: 3/86 Odometer: 20955 km (at start of testing)

Emission Control System: Feedback 2 barrel carburetter.
3 way catalyst.

Ignition Timing: 3 deg BTDC Idle Speed: 750 r/min

Inertia: 1130 kg

Date	Test No.	CYCLE RESULT (g/km) HC	CO	Nox	CO2	TEST CONDITION
28/10/86	8232	0.42	6.50	0.94	164.80	ADR 37 Test Fuel
29/10/86	8233	0.47	8.20	0.91	168.20	ADR 37 Test Fuel
30/10/86	8238	0.42	7.00	0.93	159.20	ADR 37 Test Fuel
	Avg.	0.44	7.23	0.93	164.07	
	S.D.	0.03	0.87	0.02	4.54	
6/11/86	8243	0.44	7.00	0.72	163.90	ADR 37 Test Fuel+MMT
7/11/86	8244	0.40	6.20	0.88	169.20	ADR 37 Test Fuel+MMT
10/11/86	8249	0.41	6.00	0.80	159.80	ADR 37 Test Fuel+MMT
	Avg.	0.42	6.40	0.80	164.30	
	S.D.	0.02	0.53	0.08	4.71	

MMT TEST PROGRAM

APPENDIX 3

TEST VEHICLE SPECIFICATION

Test Vehicle No. 3

Vehicle Make & Model: Toyota Corona Reg. No. NXY 530

Chassis No.: ST1419066369 Engine No. 0480473

Transmission: 3 Speed Auto. Engine Size & Type: 2000cc Inline 4

Build Date: 6/86 Odometer: 12158 km (at start of testing)

Emission Control System: 2 Barrel carburetter. 2 Way Catalyst. Air injection using air pump.

Ignition Timing: 5 deg BTDC Idle Speed: 750 r/min

Inertia: 1250 kg

	Test		CYCLE RESULT (g/km)			
Date	No.	HC	CO	NOx	CO2	TEST CONDITION
28/10/86	8230	0.20	1.70	1.08	236.50	ADR 37 Test Fuel
29/10/86	8234	0.19	1.70	1.12	233.90	ADR 37 Test Fuel
30/10/86	8237	0.18	1.70	1.12	238.90	ADR 37 Test Fuel
	Avg.	0.19	1.70	1.11	236.43	
	S.D.	0.01	0	0.02	2.50	
6/11/86	8242	0.21	1.90	0.86	230.80	ADR 37 Test Fuel+MMT
7/11/86	8245	0.20	1.70	1.06	237.70	ADR 37 Test Fuel+MMT
10/11/86	8248	0.19	1.80	0.96	230.80	ADR 37 Test Fuel+MMT
	Avg.	0.20	1.80	0.96	233.10	
	S.D.	0.01	0.10	0.10	3.98	

MMT TEST PROGRAM

APPENDIX 4

TEST VEHICLE SPECIFICATION

Test Vehicle No. 4

Vehicle Make & Model: Mitsubishi Magna Reg.No. 373 POI

Chassis No. TM2H41TB28017025 Engine No. V571U03542 TM2H41TB28017025

Transmission: 4 Speed Auto. Engine Size & Type: 2600 cc Inline 4

Build Date: 3/86 Odometer: 27897km (at start of testing)

Emission Control System: 2 Barrel carburetter. 2 Way Catalyst.
Pulse Air system.

Ignition Timing: 5 deg BTDC Idle Speed: 800 r/min

Inertia: 1360 kg

Date	Test No.	CYCLE RESULT (g/km) HC	CO	NOx	CO2	TEST CONDITION
11/11/86	8250	0.10	6.00	1.31	255.50	ADR 37 Test Fuel
12/11/86	8256	0.11	5.50	1.50	276.50	ADR 37 Test Fuel
13/11/86	8257	0.09	5.60	1.52	269.10	ADR 37 Test Fuel
21/11/86	8269	0.12	7.20	1.42	263.30	ADR 37 Test Fuel
	Avg.	0.10	6.08	1.44	266.10	
	S.D.	0.01	0.78	0.10	8.89	
18/11/86	8262	0.12	7.60	1.36	254.80	ADR 37 Test Fuel+MMT
19/11/86	8263	0.14	7.60	1.41	252.70	ADR 37 Test Fuel+MMT
20/11/86	8267	0.14	8.90	1.49	274.60	ADR 37 Test Fuel+MMT
	Avg.	0.13	8.03	1.42	260.70	
	S.D.	0.01	0.75	0.07	12.08	

MMT TEST PROGRAM

APPENDIX 5

TEST VEHICLE SPECIFICATION

Test Vehicle No. 5

Vehicle Make & Model: Ford Laser Reg. No. NVM 610

Chassis No. UK4RGY87361L Engine No. UK4RGY87361L 767382

Transmission: 3 Speed Auto. Engine Size & Type: 1600 Inline 4

Build Date: 2/86 Odometer: 33712 km (at start of testing)

Emission Control System: 2 Barrel Carburetter. 2 Way Catalyst. Pulse Air System.

Ignition Timing: 2 deg BTDC Idle Speed: 1000 r/min

Inertia: 1130 kg

Date	Test No.	CYCLE RESULT (g/km) HC	CO	NOx	CO2	TEST CONDITION
11/11/86	8251	0.34	8.10	1.51	201.70	ADR 37 Test Fuel
12/11/86	8255	0.34	7.30	1.89	209.90	ADR 37 Test Fuel
13/11/86	8258	0.40	8.40	1.54	203.30	ADR 37 Test Fuel
	Avg.	0.36	7.93	1.65	204.97	
	S.D.	0.03	0.57	0.21	4.35	
18/11/86	8261	0.43	8.80	1.61	212.10	ADR 37 Test Fuel+MMT
19/11/86	8264	0.47	8.70	1.42	198.00	ADR 37 Test Fuel+MMT
20/11/86	8268	0.41	9.10	1.49	206.00	ADR 37 Test Fuel+MMT
	Avg.	0.44	8.87	1.51	205.37	
	S.D.	0.03	0.21	0.10	7.07	
21/11/86	8270	0.92	3.90	2.49	202.40	ADR 37 Test Fuel (Signal hose found off after test)
03/12/86	8273	0.43	9.90	0.98	196.20	ADR 37 Test Fuel

MMT TEST PROGRAM

APPENDIX 5A

TEST VEHICLE SPECIFICATION

Test Vehicle No. 9

Vehicle Make & Model: Ford Laser Reg.No. 948 PTP

Chassis No. UK4RGG31139L Engine No. UK4RGG31139L 902165

Transmission: 5 Speed Manual Engine Size & Type: 1600 Inline 4

Build Date: 12/86 Odometer: 14287 km (at start of testing)

Emission Control System: 2 Barrel Carburreter. 2 Way Catalyst.
Pulse Air System

Ignition Timing: 2 deg BTDC Idle Speed: 950 r/min

Inertia: 1130 kg

	Test	CYCLE RESULT (g/km)				
Date	No.	HC	CO	NOx	CO2	TEST CONDITION
26/2/87	8352	0.24	7.5	0.60	202.9	ADR 37 Test Fuel
27/2/87	8357	0.22	7.7	0.76	199.2	ADR 37 Test Fuel
3/3/87	8365	0.22	8.2	0.84	203.9	ADR 37 Test Fuel
	Avg.	0.23	7.80	0.73	202.00	
	S.D.	0.01	0.36	0.12	2.48	
4/3/87	8370	0.21	7.4	0.75	197.2	ADR 37 Test Fuel+MMT
5/3/87	8376	0.19	6.1	0.73	194.8	ADR 37 Test Fuel+MMT
6/3/87	8380	0.21	6.6	0.64	192.1	ADR 37 Test Fuel+MMT
	Avg.	0.20	6.70	0.71	194.70	
	S.D.	0.01	0.66	0.06	2.55	

MMT TEST PROGRAM

APPENDIX 6

TEST VEHICLE SPECIFICATION

Test Vehicle No. 6

Vehicle Make & Model: Ford Falcon Reg. No. OAR 105

Chassis No. JG23GU35045C Engine No. JG23GU35045C 045377

Transmission: 3 Speed Auto. Engine Size & Type: 4100cc Inline 6

Build Date: 6/86 Odometer: 22848 km (at start of testing)

Emission Control System: 2 Barrel carburetter. 2 Way Catalyst. Pulse Air System.

Ignition Timing: 10 deg BTDC Idle Speed: 700 r/min

Inertia: 1590 kg

Date	Test No.	CYCLE RESULT HC	CO	NOx	CO2	TEST CONDITION
03/12/86	8272	0.20	2.70	1.17	302.70	ADR 37 Test Fuel
04/12/86	8274	0.24	2.30	1.22	299.70	ADR 37 Test Fuel
05/12/86	8276	0.22	2.40	1.39	310.30	ADR 37 Test Fuel
	Avg.	0.22	2.47	1.26	304.23	
	S.D.	0.02	0.21	0.12	5.46	
09/12/86	8277	0.20	2.60	1.52	318.20	ADR 37 Test Fuel+MMT
10/12/86	8278	0.22	2.40	1.45	309.30	ADR 37 Test Fuel+MMT
11/12/86	8280	0.21	1.90	0.94	263.70	ADR 37 Test Fuel+MMT*
	Avg.	0.21	2.50	1.49	313.75	
	S.D.	0.01	0.14	0.05	6.29	

*Treated as outlier

MMT TEST PROGRAM

APPENDIX 6A

TEST VEHICLE SPECIFICATION

Test Vehicle No. 7

Vehicle Make & Model: Ford Fairlane Reg. No. OAY 728

Chassis No. JH63GJ20542C Engine No. JH63GJ20542C 756487

Transmission: 3 Speed Auto. Engine Size & Type: 4100cc Inline 6

Build Date: 5/86 Odometer: 15622 km (at start of testing)

Emission Control System: Multi-point electronic fuel injection.
2 Way Catalyst.

Ignition Timing: 10 deg BTDC Idle Speed: 700 r/min

Inertia: 1820 kg

Date	Test No.	CYCLE RESULT (g/km) HC	CO	NOx	CO2	TEST CONDITION
11/11/86	8252	0.83	18.90	1.10	307.50	ADR 37 Test Fuel
	Avg.	0.83	18.90	1.10	307.50	
	S.D.					

MMT TEST PROGRAM

APPENDIX 9

TEST VEHICLE SPECIFICATION

Test Vehicle No. 9

Vehicle Make & Model: Mitsubishi Magna

Chassis No. TM2H41TB28017025

Transmission: 4 Speed Auto

Engine Size & Type: 2600 cc Inline 4

Build Date: Odometer: 20397 (at start of testing)

Emission Control System: 2 Barrel carburetter. 2 Way Catalyst. Pulse Air system.

Ignition Timing: 5 deg BTDC Idle Speed: 800 r/min

Inertia: 1360 kg

CYCLE RESULT (g/km)

HC	NO_x	CO	CO^2	TEST CONDITION
0.12	1.22	5.3	255.4	ADR 37 Test Fuel
0.14	1.23	6.2	253.7	ADR 37 Test Fuel
0.10	1.20	3.6	251.9	ADR 37 Test Fuel
Avg.				
.12	1.22	5.0	253.7	ADR 37 Test Fuel
0.12	1.26	4.6	254.2	ADR 37 Test Fuel+MMT
0.12	1.11	5.2	257.5	ADR 37 Test Fuel+MMT
0.15	1.15	7.5	258.1	ADR 37 Test Fuel+MMT
0.09	1.24	3.4	257.5	ADR 37 Test Fuel+MMT
Avg.				
.12	1.19	5.2	256.8	ADR 37 Test Fuel+MMT

MMT TEST PROGRAM

APPENDIX 10

TEST VEHICLE SPECIFICATION

Test Vehicle No. 10

Vehicle Make & Model: Mitsubishi Magna

Chassis No. TM2H41TB28017025

Transmission: 4 Speed Manual

Engine Size & Type: 2600 cc Inline 4

Build Date: Odometer: 20396km (at start of testing)

Emission Control System: Multipoint EFI/manual transmission

Ignition Timing: 5 deg BTDC Idle Speed: 800 r/min

Inertia: 1360 kg

CYCLE RESULT (g/km)

HC	NO_x	CO	CO^2	Test Condition
0.39	0.33	5.2	258.2	ADR 37 Test Fuel
0.41	0.35	5.3	252.1	ADR 37 Test Fuel
Test aborted due to low fuel and elevated fuel temperatures				
0.40	0.40	5.1	253.4	ADR 37 Test Fuel
Avg.				
.40	.36	5.2	254.6	ADR 37 Test Fuel
0.42	0.36	5.4	259.9	ADR 37 Test Fuel+MMT
0.39	0.39	5.7	252.9	ADR 37 Test Fuel+MMT
0.41	0.41	5.4	250.4	ADR 37 Test Fuel+MMT
Avg.				
.41	.39	5.5	254.4	ADR 37 Test Fuel+MMT

Summary ADR 37 Testing

Fuel: Certification Treated with 18 mg Mn/l (1)

Vehicle	Tailpipe Emissions, g/km							
	HC		CO		NOx		CO2	
	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.
SPECIFICATION	0.93		9.30		1.93		---	
Holden Commodore	0.37	.05	4.47	.58	0.10	.01	277.43	7.39
Toyota Corona	0.20	.01	1.8	.10	0.96	.10	233.10	3.98
Holden Gemini	0.42	.02	6.4	.53	0.80	.08	164.3	4.71
Mitsubishi Magna	0.13	.01	8.03	.75	1.42	.07	260.7	12.08
Ford Falcon	0.21	.01	2.50	.14	1.49	.05	313.75	6.29
Ford Laser	0.20	.01	6.7	.66	.71	.06	194.7	2.55
Ford Laser*	0.44	.02	8.87	.21	1.51	.10	205.37	7.07
Ford Fairlane*	---	---	---	---	---	---	---	---
Average, 7 car	0.281	0.138	5.539	2.70	.999	.517	---	
Average, 6 car	0.255	0.114	4.983	2.48	.913	.512	---	

		S.D.		S.D.		S.D.
7 Car 95% Confidence Interval	.281±.101	.138	5.539±1.98	2.70	.999±.379	.517
6 Car 95% Confidence Interval	.255+.094	.114	4.983±2.04	2.48	.913±.421	.521

(1) 18 mg Mn/l as "Ethyl" MMT Antiknock Compound

Summary ADR 37 Testing

Fuel: Certification Untreated

Tailpipe Emission, g/km

Vehicle	HC Ave.	HC S.D.	CO Ave.	CO S.D.	NOx Ave.	NOx S.D.	CO2 Ave.	CO2 S.D.
SPECIFICATION	0.93		9.30		1.93		---	
Holden Commodore	0.41	.03	4.63	.21	0.12	.02	279.3	2.03
Toyota Corona	0.19	.01	1.70	.00	1.11	.02	236.43	2.50
Holden Gemini	0.44	.03	7.23	.87	0.93	.02	164.07	4.54
Mitsubishi Magna	0.10	.01	6.08	.78	1.44	.10	266.1	8.98
Ford Falcon	0.22	.02	2.47	.21	1.26	.12	304.23	5.46
Ford Laser	0.23	.01	7.8	.36	0.73	.12	202.0	2.48
Ford Laser*	0.36	.03	7.93	.57	1.65	.21	204.97	4.35
Ford Fairlane*	0.83		18.9		1.1		---	
Ford Laser*	0.22		9.9		0.48		193.0	
Average, 8 Car	0.348	0.226	7.055	5.51	1.043	.468	---	
Average, 7 Car	0.278	0.128	5.362	2.56	1.034	.507	---	
Average, 6 Car	0.265	0.133	4.985	2.52	0.932	.468	---	

	HC	S.D.	CO	S.D.	NOx	S.D.
8 Car 95% Confidence Interval	.358±.151	.226	7.055±3.69	5.51	1.043±.313	.468
7 Car 95% Confidence Interval	.278±.094	.128	5.362±1.88	2.56	1.034±.372	.507
6 Car 95% Confidence Interval	.265±.109	.133	4.985±2.07	2.52	.932±.385	.468

*Note: These cars excluded in final average.

LABORATORY CORRELATION PROGRAM

I. SUMMARY

At the request of the U.S. Environmental Protection Agency, a round-robin emission testing program was established between the EPA's Motor Vehicle Emission Laboratory at Ann Arbor, Michigan and two laboratories that Ethyl Petroleum Additives, Inc. has used in support of the waiver application for the HiTEC® 3000 Performance Additive ("the Additive"). The two laboratories are ECS Laboratories, Livonia, Michigan and Southwest Research Institute (SwRI), San Antonio, Texas.

The objective of the testing program was to correlate (1) gaseous automotive exhaust emissions between EPA's laboratory and ECS laboratory and (2) particulate automotive emissions between EPA's laboratory and SwRI. Two automobiles were used in the testing program; a low-mileage 1991 Chrysler LeBaron and a 1988 Buick Century from the Ethyl test fleet which had accumulated over 75,000 miles with gasoline containing the HiTEC 3000 Performance Additive.

The results of the round-robin testing program indicate good agreement between all three laboratories. Each laboratory followed the same test protocol and used the same fuel in conducting the emission testing. The gaseous emissions obtained by ECS Laboratory and SwRI were very similar to those obtained by EPA's laboratory and were all within the statistical limits for acceptable correlation as calculated by the Correlation Group of the Engineering Operations Division of EPA's Motor Vehicle Emission Laboratory

II. BACKGROUND

Ethyl first submitted this waiver application for HiTEC 3000 Performance Additve on May 9, 1990. The test program consisted of an extensive fleet test of 48 cars which were driven 75,000 miles each. Twenty-four cars were fueled with Howell EEE gasoline and the other 24 cars were fueled with Howell EEE gasoline plus the Additive at 0.03125 gm Mn/gallon. Gaseous emission tests were conducted every 5,000 miles while a few cars were tested for particulate emissions at the end of 75,000 miles.

At the end of the testing program, Ethyl used two independent consultants to statistically analyze the data. The data analysis indicated a small average increase in HC emissions of 0.018 gm/mile with the use of HiTEC 3000 Performance Additive, while CO and NOx decreased, on average, by 0.22 gm/mile and 0.11 gm/mile, respectively. Ethyl also reported that, on the basis of testing 18 cars at the end of 75,000 miles, particulate emissions were essentially unaffected by use of the Additive.

As part of the evaluation of Ethyl's waiver application, EPA's Motor Vehicle Emission Laboratory initiated a limited test program to measure gaseous and particulate emissions from a limited number of vehicles using either Phillips unleaded gasoline and/or Phillips unleaded gasoline plus HiTEC 3000 Performance Additive at approximately 0.03 gm Mn/gallon. The EPA tested six American rental cars, three Canadian rental cars and six cars from the Ethyl test fleet. All emission testing was done using the EPA diesel particulate tunnel.

The results of the EPA gaseous emission tests on the Ethyl fleet cars indicated a higher average HC increase for HiTEC 3000 Performance Additive than reported by Ethyl, as well as higher particulate emissions. See filing reference IV-A-2 of EPA Docket A-90-16.

Since there was a difference in the physical configuration of the ECS particulate tunnel and the EPA particulate tunnel, Ethyl decided to construct one to EPA's specification. Ethyl contracted with SwRI to construct this tunnel and then conduct some emission tests with a few low-mileage rental cars and some Ethyl test fleet cars.

The results of the SwRI particulate emission testing indicated a small increase in particulates with HiTEC 3000 Performance Additive but nothing like the large increases obtained by the EPA laboratory. For example, the average results on the five cars tested at SwRI for the FTP cycle were 0.005 gm/mile for clear fuel and 0.007 gm/mile for fuel containing HiTEC 3000. A detailed description of the SwRI testing is given in Appendix 5.

The results of the SwRI particulate data and ECS gaseous emission data were presented to the EPA Mobile Sources group on March 26, 1991. It was at this meeting that EPA decided that a correlation program should be conducted between EPA/ECS/SwRI.

III. CORRELATION TEST PROTOCOL

A meeting was held between Ethyl representatives and EPA Motor Vehicle Emission Laboratory personnel on April 2, 1991 to discuss details of a correlation test program to resolve the differences in gaseous and particulate emission measurements obtained by EPA and Ethyl's consultants. A decision was made to use two automobiles; a low-mileage 1991 Chrysler LeBaron and an Ethyl fleet car that had accumulated mileage with HiTEC 3000. The specific fleet car chosen was car I-4.

The base fuel used for the program was Howell EEE. The test cycle used for each day's testing was an FTP followed by a double highway cycle. ECS Laboratories only measured gaseous emissions while both SwRI and EPA's laboratory measured gaseous and particulate emissions. A detailed description of the test protocol is given in Attachment 1.

IV. TEST RESULTS

The results of the correlation test program between EPA/ECS/SwRI exhibit very good agreement in emission measurements between the three laboratories. Plus, there were no large increases in gaseous or particulate emissions when HiTEC 3000 was added to the gasoline. Also, the particulate emission measurements were very low for both cars; the average values were all below 0.009 gm/mile. The results of this correlation program clearly demonstrate that the emission results obtained by Ethyl's consultant laboratories during the fleet test program and ensuing data measurements are valid.

Emission measurements for the low-mileage vehicle, a 1991 Chrysler LeBaron, were obtained on only gasoline containing HiTEC 3000 Performance Additive. Three individual measurements were taken at each of the three laboratories. The average of the three gaseous emission ratings were almost identical between ECS Laboratories and EPA's laboratory. For example, for the FTP cycle, HC emissions averaged 0.364 gm/mile at ECS compared to 0.350 gm/mile at EPA. CO and NOx emission measurements between the two laboratories exhibited similar agreement. Likewise, the average particulate emissions for the low-mileage vehicle were very small and quite similar between SwRI and EPA; 0.008 gm/mile versus 0.006 gm/mile. The emission data obtained by the three laboratories for the low-mileage vehicle are shown in Attachments 2 through 4. These data tables were prepared by the Engineering Operations Division of EPA's Motor Vehicle Emissions Laboratory in Ann Arbor, Michigan.

The other vehicle in the correlation test program was an Ethyl fleet car that has accumulated over 77,000 miles on gasoline containing HiTEC 3000 Performance Additive. The car is a 1988 Buick Century with a 3.8L engine. Six separate emission measurements were obtained by each laboratory on this vehicle; 3 made with gasoline containing the Additive and 3 made without the Additive.

The gaseous emission data obtained by the three laboratories for the Ethyl fleet car were very similar. Also, there was very little difference between measurements made with and without HiTEC 3000 Performance Additive. For example, the table below compares FTP cycle HC emissions obtained by the three laboratories with and without the Additive:

AVERAGE HYDROCARBON EMISSIONS - FTP CYCLE
EPA/ECS/SwRI Correlation Study

Laboratory	gm/mile With HiTEC 3000	Without HiTEC 3000	Diff.[1]
EPA	0.192	0.191	0.001
ECS	0.207	0.196	0.011
SwRI	0.20	0.21	-0.01

[1]Difference is "With HiTEC 3000" minus "Without HiTEC 3000".

Similar results were obtained for CO and NOx emission measurements and are reported in Attachments 5 through 7.

Particulate emission measurements obtained by SwRI and the EPA laboratories for the Ethyl fleet car were also similar and very small in absolute value; and, the differences between particulate emissions measured with gasoline containing HiTEC 3000 Performance Additive and without the Additive were also quite small, as is shown in the following table:

AVERAGE PARTICULATE EMISSIONS - FTP CYCLE
EPA/ECS/SwRI Correlation Study

Laboratory	gm/mile With HiTEC 3000	Without HiTEC 3000	Diff.[1]
EPA	0.004	0.003	0.001
SwRI	0.003	0.003	0.000

[1]Difference is "With HiTEC 3000" minus "Without HiTEC 3000".

The rest of the particulate data for the Ethyl fleet car is shown in Attachments 5 through 7. The results of the Total Hydrocarbon Gas Bottle analysis obtained by the three laboratories are shown in Attachment 8.

V. CONCLUSIONS

This correlation test program conducted with Howell EEE gasoline confirms the results obtained by the independent laboratories retained by Ethyl as a part of the 48 car test program.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

Attachment 1

April 9, 1991

OFFICE OF
AIR AND RADIATION

Don P. Hollrah
Product Manager
Ethyl Petroleum Additives, Inc.
20 South 4th Street
St. Louis, MO 63102-1886

Dear Mr. Hollrah:

Enclosed is our proposed test plan based on our meeting Wednesday and further discussion with our lab personnel. I think you will find the plan essentially as we discussed Wednesday, but a few points require further clarification:

1. We recommend installing two fresh "slave" canisters on each vehicle per attached sketch. This should guarantee that canister condition will not have any effect on hydrocarbon measurement.

2. The test sequence for the low mileage vehicle includes a return test at ECS. It is EPA policy, and long standing practice for correlation testing with automobile manufacturers, to provide for this sort of closure.

For the high mileage vehicle, we would like to use a vehicle from one of the three families of cars originally tested at EPA, a 5.0L Ford Crown Victoria, 2.8L Buick Century or 2.5L Buick Century. I will be talking with you within the next few days to select the specific vehicles to be used and to further coordinate our testing effort.

Sincerely yours,

Tom Schrodt

Tom Schrodt, Mechanical Engineer
Correlation and Engineering Services
U.S. EPA Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, MI 48105

Enclosure

EPA / ECS / SWRI CORRELATION TEST PLAN

April 4, 1991

The following describes a test plan to be used to investigate the level of correlation between EPA's Motor Vehicle Emission Laboratory in Ann Arbor, Michigan and two laboratories engaged in contract work for Ethyl Corporation, ECS Laboratory in Livonia, Michigan and Southwest Research Institute in San Antonio Texas.

Vehicles

Two vehicles will be used for the purpose of this study; one vehicle will be a high mileage accumulation vehicle run for extended periods of time on gasoline with MMT, the other vehicle a low mileage vehicle used as part of the recent MMT research conducted at Southwest Research. The specific vehicles will be selected by Ethyl Corporation and EPA based on relative stability of emission levels during previous testing programs. Testing protocols will be somewhat different for the two vehicles. In particular the high mileage car will be run on both fuel treated with MMT and clear fuel while the low mileage car will be run on treated fuel only. Gaseous and particulate emission will be measured on both vehicles. Both vehicles will be equipped with separate, isolated fill and purge evaporative canisters to eliminate canister effects from total hydrocarbon emission measurements.

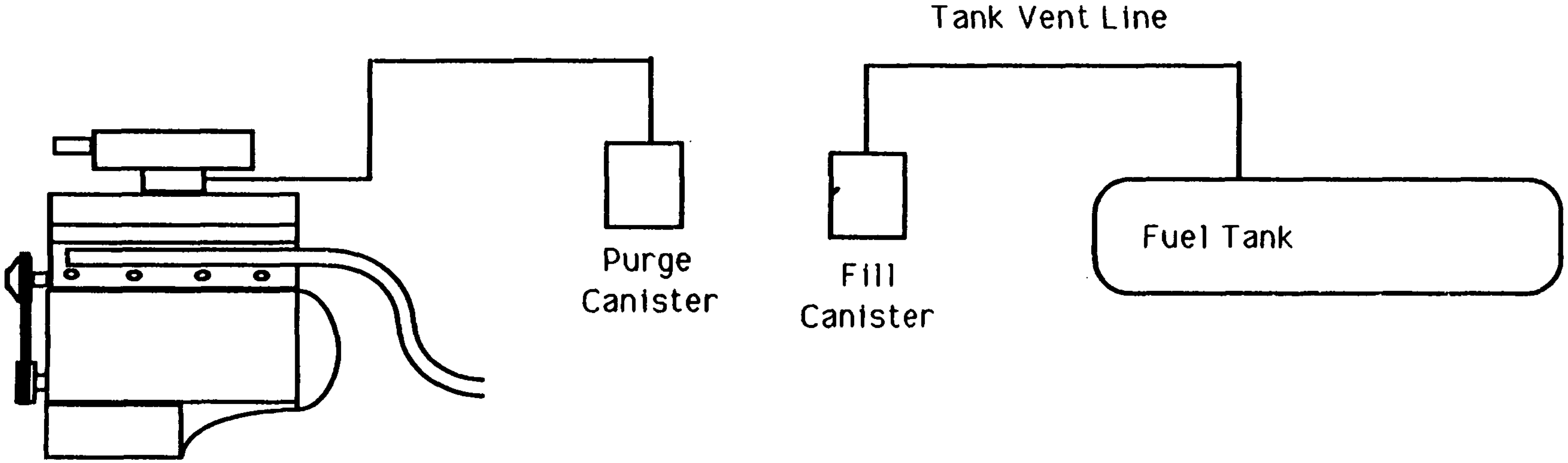
All fuel will be Howell EEE, provided by Ethyl Corporation. MVEL will provide a propane and methane cylinder to be analyzed at each testing site.

High Mileage Vehicle

The high mileage vehicle will be run six times on the same dynamometer at each laboratory, three runs with clear fuel followed by three runs with fuel treated with MMT. In addition, at EPA this will be followed by three runs on a second certification dynamometer with fuel treated with MMT (gaseous emission measurement only). The testing will proceed in the following order: SWRI, ECS, EPA, SWRI. The testing protocol will be as follows:

Engineering Operations Division
Evaporative Canister Configuration
EPA/ECS/SwRI Correlation Test

Suggested Configuration



Week 1:

Day 1. Drain fuel, fill tank to 100% with clear test fuel. Install fresh "fill" evaporative canister . Prep car by running a HFET test cycle (For purposes of this plan the HFET cycle should be considered to consist of one warmup + one measurement cyle, appoximately 22 miles total). Top off fuel tank to the 100% level and soak vehicle overnight.

Day 2. Perform FTP test, followed by two consecutive HFET cycles. Sample particulate emission with one filter set (primary and secondary) during FTP and a second filter set during the warmup and sample portions of both HFET cycles. Measure gaseous emission during the measurement portion of the first HFET cycle only. Top off fuel tank to 100% level and soak vehicle overnight.

Day 3. Same as day 2.

Day 4. Same as day 2.

Day 5. Makeup void test if necessary.

Week 2:

Day 1. Drain fuel and refill tank with MMT treated fuel. Follow balance of test protocol from week 1.

Week 3. (EPA only)

Do not drain, but refill tank to 100% with MMT treated fuel. Follow the test protocol for week two using a second certification dynamometer and measure gaseous emission only. Run a single HFET cycle each testing day.

<u>Low Mileage Vehicle</u>

The low mileage vehicle will be run three times at each laboratory, all testing will be performed with fuel treated with MMT. The testing will proceed in the following order: ECS, EPA, SWRI, ECS.

Day 1. Drain fuel, fill tank to 100% with treated test fuel. Prep car by running HFET test cycle. Top off fuel tank to 100% level and soak vehicle overnight.

Day 2. Perform FTP test, followed by two consecutive HFET cycles. Sample particulate emission with one filter set (primary and secondary) during FTP and a second filter set during the warmup and sample portions of both HFET cycles. Measure gaseous emission during the measurement portion of the first HFET cycle only. Top off fuel tank to 100% level and soak vehicle overnight.

Day 3. Same as day 2.

Day 4. Same as day 2.

Day 5. Makeup void test if necessary.

Both Vehicles

Measure HC, CO, NOx, CO2 and FE for the FTP and for the sample portion of the first HFET cycle each day. Measure particulate for each FTP and during the warm-up and sample portions of both HFET cycles each day.

Verify tire pressure at 45 psi (cold) at the start of each testing day.

Utilize EPA filter type, nominal flow rates and particulate probe configuration for all particulate testing.

Fan placement as follows: front fan (angle down) + side fan (angle down).

No more than 30 minutes between FTP and HFET tests. Hood down and fans off between FTP and HFET tests. Testing may continue if 30 minutes are exceeded, by running a 505 cycle as a warm-up, but this should be avoided.

One driver should be used at each laboratory for all testing on a particular vehicle.

Check the "fill" evaporative canister at the end of each day's testing, replace with fresh canister as necessary.

No heat builds.

Quality Control

The final HFET each day will be immediately followed by three quickcheck coastdowns which do not differ by more than 0.3 seconds from each other. A total of five coastdowns may be run to achieve three coastdown times within 0.3 seconds of each other. If this criteria can not be met, that day's testing should be considered void. Coastdowns are to be run by accelerating at approximately 2 MPH/second to 65 MPH, holding at 64 to 66 MPH for approximately 2 seconds, shifting to neutral and coasting down. Coastdown time is to be measured between 55 and 45 MPH and reported along with other test data.

In addition, each laboratory will also furnish the following data:

1. Results and date of most current analyzer curve checks.

2. Results and date of most recent dynamometer calibration or verification.

3. Results and date of most recent CVS verification.

4. Results and date of most recent gas meter calibration

5. Date of last balance calibration.

6. Ambient weighing chamber conditions (temperature and humidity) during the course of testing.

7. Result of analyses of propane and methane gas bottles to be provided by EPA.

8. Drivers traces should be available on request for troubleshooting purposes.

ENGINEERING OPERATIONS DIVISION

Attachment 2

ETHYL / EPA CORRELATION TEST PROGRAM
FTP RESULTS - LOW MILEAGE VEHICLE

VEHICLE:	1991 Chrysler Lebaron 3.0L		FUEL:	Howell EEE
VIN:	1C3XJ4532MG106621			with 0.03 g./gal. Mn
IW:	3875 Pounds	HP: 8.1 HP		

Date	Odometer	Lab	Fuel	THC GPM	CO GPM	NOx GPM	CO2 GPM	F.E. MPG	Part. GPM
4/16/91	10546	ECS	MMT	0.348	2.019	0.343		21.43	not meas
4/17/91	10605	ECS	MMT	0.365	1.867	0.337		21.67	not meas
4/18/91	10664	ECS	MMT	0.379	2.036	0.344		21.05	not meas
	Mean			0.364	1.974	0.341		21.38	
ECS	Standard Deviation			0.015	0.093	0.004		0.31	
	%Diff from EPA			4.1	-2.0	6.8		-0.9	
5/1/91	10745	EPA	MMT	0.318	1.958	0.332	404	21.64	0.007
5/2/91	10801	EPA	MMT	0.355	2.017	0.319	407	21.47	0.004
5/8/91	10911	EPA	MMT	0.377	2.065	0.308	404	21.62	0.008
EPA	Mean			0.350	2.013	0.320	405.0	21.58	0.006
	Standard Deviation			0.030	0.054	0.012	1.7	0.09	0.001
5/15/91	10990	SWRI	MMT	0.32	1.67	0.35		21.02	0.0127
5/16/91	11046	SWRI	MMT	0.40	1.89	0.49		21.11	0.0067
5/17/91	11104	SWRI	MMT	0.40	1.89	0.41		20.89	0.0058
5/20/91	11168	SWRI	MMT	0.38	2.09	0.44		20.98	0.0067
	Mean			0.38	1.89	0.42		21.00	0.0080
SWRI	Standard Deviation			0.04	0.17	0.06		0.09	0.0032
	%Diff from EPA			7.1	-6.4	32.2		-2.7	40.7

ENGINEERING OPERATIONS DIVISION

Attachment 3

ETHYL / EPA CORRELATION TEST PROGRAM
HFET RESULTS - LOW MILEAGE VEHICLE

VEHICLE: 1991 Chrysler Lebaron 3.0L
VIN: 1C3XJ4532MG106621
IW: 3875 Pounds HP: 8.1 HP

FUEL: Howell EEE with 0.03 g./gal. Mn

Date	Odometer	Lab	Fuel	THC GPM	CO GPM	NOx GPM	CO2 GPM	F.E. MPG	Part. GPM
4/16/91	10568	ECS	MMT	0.07	0.52	0.21		33.30	not meas
4/17/91	10627	ECS	MMT	0.06	0.48	0.18		33.66	not meas
4/18/91	10686	ECS	MMT	0.07	0.57	0.18		33.29	not meas
ECS	Mean			0.07	0.52	0.19		33.42	
	Standard Deviation			0.01	0.05	0.02		0.21	
	%Diff from EPA			-4.4	9.3	83.3		-0.7	
5/1/91	10756	EPA	MMT	0.069	0.481	0.110	260	33.83	0.002
5/2/91	10817	EPA	MMT	0.067	0.453	0.104	262	33.58	0.008
5/8/91	10923	EPA	MMT	0.070	0.502	0.097	262	33.57	0.009
EPA	Mean			0.069	0.479	0.104	261.33	33.66	0.006
	Standard Deviation			0.002	0.025	0.007	1.15	0.15	0.003
5/15/91	11011	SWRI	MMT	0.07	0.49	0.15		33.80	0.0027
5/16/91	11068	SWRI	MMT	0.06	0.45	0.12		34.20	0.0025
5/17/91	11126	SWRI	MMT	0.07	0.46	0.14		34.20	0.0026
5/20/91	11179	SWRI	MMT	0.08	0.44	0.19		35.90	0.0018
SWRI	Mean			0.07	0.46	0.15		34.53	0.0024
	Standard Deviation			0.01	0.02	0.03		0.94	0.0004
	%Diff from EPA			1.9	-3.9	44.7		2.6	-62.1

ENGINEERING OPERATIONS DIVISION

Attachment 4

ETHYL / EPA CORRELATION TEST PROGRAM
QC RESULTS - LOW MILEAGE VEHICLE

VEHICLE: 1991 Chrysler Lebaron 3.0L
VIN: 1C3XJ4532MG106621
IW: 3875 Pounds HP: 8.1 HP

FUEL: Howell EEE
with 0.03 g./gal. Mn

Date	Odometer	Lab	Quick Check Coastdowns (seconds) CD-1	CD-2	CD-3	Average
4/16/91	10568	ECS	18.65	18.63	18.85	18.71
4/17/91	10627	ECS	18.51	18.36	18.48	18.45
4/18/91	10686	ECS	18.31	18.52	18.48	18.44
Mean						18.53
Standard Deviation						0.16
%Diff from EPA						3.7
5/1/91	10756	EPA	17.80	17.79	18.05	17.88
5/2/91	10817	EPA	17.81	17.98	17.92	17.90
5/8/91	10923	EPA	17.82	17.81	17.80	17.81
Mean						17.86
Standard Deviation						0.10
5/15/91	11011	SWRI	17.78	18.22	18.13	18.04
5/16/91	11068	SWRI	18.60	18.28	18.16	18.35
5/17/91	11126	SWRI	17.94	18.13	18.08	18.05
5/20/91	11179	SWRI	18.66	18.54	18.55	18.58
Mean						18.26
Standard Deviation						0.28
%Diff from EPA						2.2

ENGINEERING OPERATIONS DIVISION

ETHYL / EPA CORRELATION TEST PROGRAM
FTP RESULTS - HIGH MILEAGE VEHICLE

Attachment 5

VEHICLE: 1988 Buick Century 3.8L BASE FUEL: HOWELL EEE
VIN: 1G4AH5130JT454280
IW: 3625 Pounds HP: 7.2 HP

Date	Odometer	Lab	Fuel	THC GPM	CO GPM	NOx GPM	CO2 GPM	F.E. MPG	Part. GPM
4/16/91	76058	SWRI	CLEAR	0.19	2.41	0.21		19.84	0.0028
4/17/91	76114	SWRI	CLEAR	0.20	2.26	0.21		19.54	0.0027
4/18/91	76171	SWRI	CLEAR	0.23	2.68	0.21		19.67	0.0034
SWRI	Mean			0.21	2.45	0.21		19.68	0.0030
CLEAR	Standard Deviation			0.02	0.21	0.00		0.15	0.0004
FUEL	%Diff from EPA			8.4	21.3	11.1		-2.3	-11.0
4/19/91	76248	SWRI	MMT	0.21	2.35	0.21		19.71	0.0027
4/22/91	76311	SWRI	MMT	0.21	2.53	0.18		19.74	0.0042
4/23/91	76366	SWRI	MMT	0.19	2.10	0.23		20.00	0.0021
SWRI	Mean			0.20	2.33	0.21		19.82	0.0030
MMT	Standard Deviation			0.01	0.22	0.03		0.16	0.0011
FUEL	%Diff from EPA			5.7	12.1	35.1		-2.1	-30.8
4/29/91	76453	ECS	CLEAR	0.180	1.780	0.232		20.38	not meas.
4/30/91	76511	ECS	CLEAR	0.203	2.172	0.220		19.98	not meas.
5/1/91	76570	ECS	CLEAR	0.205	2.324	0.231		19.94	not meas.
ECS	Mean			0.196	2.092	0.228		20.10	
CLEAR	Standard Deviation			0.014	0.281	0.007		0.24	
FUEL	%Diff from EPA			2.8	3.6	20.5		-0.3	
5/2/91	76679	ECS	MMT	0.203	2.387	0.185		20.28	not meas.
5/3/91	76764	ECS	MMT	0.202	2.141	0.163		20.18	not meas.
5/4/91	76833	ECS	MMT	0.215	2.683	0.147		20.45	not meas.
ECS	Mean			0.207	2.404	0.165		20.30	
MMT	Standard Deviation			0.007	0.271	0.019		0.14	
FUEL	%Diff from EPA			7.5	15.8	7.8		0.3	
5/14/91	76958	EPA	CLEAR	0.187	1.880	0.181		20.50	0.004
5/17/91	77022	EPA	CLEAR	0.193	2.175	0.194		20.02	0.003
5/22/91	77095	EPA	CLEAR	0.182	1.992	0.192		19.95	0.003
EPA	Mean			0.191	2.019	0.189		20.16	0.003
CLEAR	Standard Deviation			0.008	0.144	0.007		0.30	0.001
5/30/91	77173	EPA	MMT	0.191	2.073	0.136		20.31	0.003
5/31/91	77227	EPA	MMT	0.191	2.066	0.179		20.22	0.006
6/1/91	77291	EPA	MMT	0.195	2.09	0.144		20.17	0.004
EPA	Mean			0.192	2.076	0.153		20.23	0.004
MMT	Standard Deviation			0.002	0.012	0.023		0.07	0.002

ENGINEERING OPERATIONS DIVISION

ETHYL / EPA CORRELATION TEST PROGRAM
HFET RESULTS - HIGH MILEAGE VEHICLE

Attachment 6

VEHICLE: 1988 Buick Century 3.8L
VIN: 1G4AH5130JT454280
IW: 3625 Pounds HP: 7.2 HP

BASE FUEL: HOWELL EEE

Date	Odometer	Lab	Fuel	THC GPM	CO GPM	NOx GPM	CO2 GPM	F.E. MPG	Part. GPM
4/16/91	76079	SWRI	CLEAR	0.09	0.21	0.02		36.5	0.0014
4/17/91	76136	SWRI	CLEAR	0.07	0.19	0.02		37.2	0.0008
4/18/91	76192	SWRI	CLEAR	0.06	0.15	0.03		37.9	0.0010
SWRI	Mean			0.07	0.18	0.02		37.20	0.0011
CLEAR	Standard Deviation			0.02	0.03	0.01		0.70	0.0003
FUEL	%Diff from EPA			-32.3	-43.6	0.0		3.6	-36.0
4/19/91	76269	SWRI	MMT	0.06	0.18	0.02		37.3	0.0011
4/22/91	76332	SWRI	MMT	0.06	0.17	0.02		37.3	0.0011
4/23/91	76386	SWRI	MMT	0.09	0.29	0.02		38.3	0.0008
SWRI	Mean			0.07	0.21	0.02		37.63	0.0010
MMT	Standard Deviation			0.02	0.07	0.00		0.58	0.0002
FUEL	%Diff from EPA			-34.8	-38.2	13.2		1.0	-83.3
4/29/91	76475	ECS	CLEAR	0.047	0.178	0.031		36.38	not meas.
4/30/91	76533	ECS	CLEAR	0.047	0.114	0.047		36.35	not meas.
5/1/91	76675	ECS	CLEAR	0.074	0.186	0.025		37.32	not meas.
ECS	Mean			0.056	0.159	0.034		36.68	
CLEAR	Standard Deviation			0.016	0.039	0.011		0.55	
FUEL	%Diff from EPA			-48.3	-51.0	47.1		2.1	
5/2/91	76701	ECS	MMT	0.093	0.236	0.010		35.59	not meas.
5/3/91	76807	ECS	MMT	0.068	0.213	0.051		35.72	not meas.
5/4/91	76854	ECS	MMT	0.064	0.215	0.014		35.84	not meas.
ECS	Mean			0.075	0.221	0.025		35.72	
MMT	Standard Deviation			0.016	0.013	0.023		0.13	
FUEL	%Diff from EPA			-30.1	-35.8	41.5		-4.1	
5/14/91	76969	EPA	CLEAR	0.109	0.301	0.020		36.36	0.001
5/17/91	77033	EPA	CLEAR	0.100	0.282	0.022		35.64	0.003
5/22/91	77106	EPA	CLEAR	0.116	0.393	0.028		35.76	0.001
EPA	Mean			0.108	0.325	0.023		35.92	0.002
CLEAR	Standard Deviation			0.008	0.059	0.004		0.39	0.001
5/30/90	77184	EPA	MMT	0.107	0.342	0.018		36.21	0.003
5/31/91	77238	EPA	MMT	0.112	0.364	0.017		39.61	0.006
6/1/91	77280	EPA	MMT	0.103	0.328	0.018		35.92	0.009
EPA	Mean			0.107	0.345	0.018		37.25	0.006
MMT	Standard Deviation			0.005	0.018	0.001		2.05	0.003

ENGINEERING OPERATIONS DIVISION

Attachment 7

ETHYL / EPA CORRELATION TEST PROGRAM
QC RESULTS - HIGH MILEAGE VEHICLE

VEHICLE: 1988 Buick Century 3.8L BASE FUEL: HOWELL EEE
VIN: 1G4AH5130JT454280
IW: 3625 Pounds HP: 7.2 HP

				Quick Check Coastdowns (seconds)			
Date	Odometer	Lab	Fuel	CD-1	CD-2	CD-3	Average
4/16/91	76079	SWRI	CLEAR	18.00	18.10	18.00	18.03
4/17/91	76136	SWRI	CLEAR	18.09	17.97	18.13	18.06
4/18/91	76192	SWRI	CLEAR	18.63	18.45	18.60	18.56
SWRI	Sequence Average						18.22
CLEAR	Sequence Standard Deviation						0.27
FUEL	%Diff from EPA						4.4
4/19/91	76269	SWRI	MMT	18.24	18.35	18.34	18.31
4/22/91	76332	SWRI	MMT	18.62	18.53	18.56	18.57
4/23/91	76388	SWRI	MMT	18.39	18.12	18.25	18.25
SWRI	Sequence Average						18.38
MMT	Sequence Standard Deviation						0.17
FUEL	%Diff from EPA						5.7
4/29/91	76475	ECS	CLEAR	18.44	18.62	18.62	18.56
4/30/91	76533	ECS	CLEAR	18.44	18.56	18.60	18.53
5/1/91	76675	ECS	CLEAR	18.31	18.61	18.31	18.41
	Sequence Average						18.50
	Sequence Standard Deviation						0.13
	%Diff from EPA						6.0
5/2/91	76701	ECS	MMT	18.20	18.32	18.40	18.31
5/3/91	76807	ECS	MMT	18.26	18.28	18.18	18.24
5/4/91	76854	ECS	MMT	18.31	18.39	18.41	18.37
	Sequence Average						18.31
	Sequence Standard Deviation						0.08
	%Diff from EPA						5.3
5/14/91	76968	EPA	CLEAR	17.56	17.46	17.59	17.54
5/17/91	77033	EPA	CLEAR	not meas.	not meas.	not meas.	
5/22/91	77106	EPA	CLEAR	17.29	17.34	17.44	17.36
	Sequence Average						17.45
	Sequence Standard Deviation						0.12
5/30/90	77184	EPA	MMT	17.32	17.35	17.54	17.40
5/31/91	77238	EPA	MMT	not meas	not meas	not meas	
6/1/91	77280	EPA	MMT	17.36	17.33	17.44	17.38
	Sequence Average						17.39
	Sequence Standard Deviation						0.08

ENGINEERING OPERATIONS DIVISION

Attachment 8

ETHYL / EPA CORRELATION TEST PROGRAM
QC RESULTS - HIGH MILEAGE VEHICLE

VEHICLE: 1988 Buick Century 3.8L
BASE FUEL: HOWELL EEE
VIN: 1G4AH5130JT454280
IW: 3625 Pounds HP: 7.2 HP

RESULTS OF TOTAL HYDROCARBON GAS BOTTLE ANALYSIS:

LAB	METHANE BOTTLE FF.12059	PROPANE BOTTLE CAL-2659
ECS	18.8 ppmC	290 ppmC
SWRI	18.2 ppmC	288 ppmC
EPA-A004	20.0 ppmC	296 ppmC
EPA-GAS LAB ANALYSIS	16.05 ppm Methane (16.05 ppmC)	95.97 ppm Propane (287.9 ppmC)

NOTE: ALL ANALYSES PERFORMED ON A TOTAL HYDROCARBON FID WITH PROPANE AS THE STANDARD, EXCEPT THE EPA GAS LAB ANALYSIS OF THE METHANE BOTTLE. THIS GAS WAS NAMED WITH A METHANE STANDARD AND ANALYZED BY GC.

FUEL-SPECIFIC GASEOUS/PARTICULATE EMISSION TEST PROGRAM

I. SUMMARY

Ethyl Corporation has recently conducted emission testing at two independent laboratories to study if there is a fuel-specific emissions effect associated with the use of HiTEC® 3000 Performance Additive ("the Additive"). The two laboratories are ECS Laboratories ("ECS"), Livonia, Michigan and Southwest Research Institute ("SwRI"), San Antonio, Texas. Two fuels were used in the study; a certification fuel from Sun Oil Company and a Texaco commercial premium gasoline purchased in San Antonio, Texas.

The results of the testing program indicate that other fuels containing HiTEC 3000 Performance Additive would provide the same type of emission characteristics as provided by Howell EEE, the gasoline used in the Ethyl 48-car fleet test program. The test results clearly demonstrate that gaseous and particulate emissions measured from these other fuels with the Additive are essentially identical to those from the same fuels without the Additive. That is, there is no fuel-specific emissions effect associated with the use of the Additive.

II. BACKGROUND

On May 17, 1991 personnel from the Motor Vehicle Emissions Laboratory of the U.S. Environmental Protection Agency requested a meeting with representatives of Ethyl Corporation. At this meeting, the EPA representatives provided emission test results from one car that showed large increases in gaseous and particulate emissions when HiTEC 3000 Performance Additive was added to the fuel. The actual test results from EPA are discussed and shown in Appendix 2. The fuel used was a Sun Oil Company certification fuel which is similar in characteristics to Howell EEE certification gasoline. Characteristics of the Sun fuel are shown in Table 1. */

The EPA testing laboratory did make one run using Howell EEE with the Additive. The test results obtained were similar to those obtained by independent laboratories used by Ethyl in their 48-car fleet test program. But, the next test run was conducted using the Sun fuel plus the Additive and the gaseous and particulate emissions again showed a higher increase.

Ethyl has never seen this fuel-specific instantaneous emission effect with HiTEC 3000 Performance Additive in over 15 years of emission test work. Ethyl obtained the Sun Oil certification fuel from EPA and originated a testing program at ECS and SwRI. to determine whether a fuel-specific emission effect would occur.

---

*/ A comparison of the characteristics of Sun Oil certification fuel with those of other test fuels used by the Agency and others for purposes of testing the Additive are shown in Table 1A.

III. TEST RESULTS

Gaseous emissions were obtained on two automobiles at ECS Laboratories using the Sun Oil certification fuel with and without the Additive. The two automobiles were a 1990 Ford Crown Victoria with approximately 16,000 miles and an Ethyl fleet car, G-6, a 2.5L Buick with over 75,000 miles accumulated on Howell EEE gasoline containing the Additive. The test protocol used was a standard CVS prep that was used in the 75,000 mile fleet test program. In addition, the prep for the last three runs (June 10,11,12) on the Ford Crown Victoria, listed in Table 2, included a diurnal heat build. Before testing began with the Ford Crown Victoria, approximately 300 road miles were accumulated with fuel containing HiTEC 3000 Performance Additive.

The gaseous emissions collected on the two automobiles using the Sun and Howell EEE certification fuel were essentially the same when data without the Additive are compared to data with the Additive. For example, the table below compares average HC emissions obtained from the two automobiles using the Sun fuel with and without the Additive:

AVERAGE HYDROCARBON EMISSIONS - FTP CYCLE
ECS Laboratories

gm/mile

Car	Fuel	With HiTEC 3000	Without HiTEC 3000	Diff.
Ford Cr. Vict.	Sun	0.222	0.235	-0.013
Ford Cr. Vict.	EEE	0.240	0.250	-0.010
2.5L Buick	Sun	0.179	0.174	0.005
2.5L Buick	EEE	0.163	--	--

Note - Difference is With HiTEC 3000 minus Without HiTEC 3000.

A diurnal heat build was included in the prep routine for the Ford Crown Victoria on the runs conducted on June 10, 11, and 12, 1991. The diurnal heat build had no effect on the HC emissions.

Analysis of average CO and NOx emission measurements for the two cars also show results similar to HC emission data, i.e., very small changes in emissions when comparing the same fuel with and without the Additive. The CO and NOx emission data are reported in Table 2.

At SwRI, gaseous and particulate emissions were measured on one car using the Sun Oil certification fuel and a Texaco commercial premium gasoline with and without the Additive. The laboratory properties of the Texaco fuel are shown in Table 3.

The automobile used was a 1991 Chrysler LeBaron which was also used in the Correlation Test Program described in Appendix 3 and the particulate study program described in Appendix 5. Due to the nature of these two programs, this car had accumulated over 1,000 miles with fuel containing the Additive prior to this round of testing. In addition, between the emission test conducted on 6/7/91 and 6/10/91 (shown in Table 4), an additional 250 road miles were accumulated on Texaco premium containing the additive. Likewise, the same holds true between the test conducted on 6/12/91 and 6/14/91 except that the fuel was Sun certification containing the Additive.

The protocol used was a standard CVS-prep without a diurnal heat build except that a triple LA-4 was used in the prep when fuel types were changed.

Gaseous emissions obtained on three different fuels indicate that there is not a fuel-specific effect with HiTEC 3000 Performance Additive. However, a specific fuel can have an effect on gaseous emissions, in general, independent of the Additive. For example, HC emissions for Texaco premium without the Additive are about 0.1 gm/mile higher than for Howell EEE without the Additive, but there is no further increase in emissions when the Additive is added to the Texaco premium fuel (See Table 4). The table below compares average HC emissions for three different fuels with and without the Additive.

AVERAGE HYDROCARBON EMISSIONS - FTP CYCLE
SwRI - 3.0L Chrysler LeBaron

gm/mile

Fuel	With HiTEC 3000	Without HiTEC 3000	Diff.[1]
Howell EEE	0.375	0.360	0.015
Texaco Prem.	0.450	0.495	-0.045
Sun Cert.	0.340	0.350	-0.010

[1]Difference is "With HiTEC 3000" minus "Without HiTEC 3000".

Similar results were obtained for CO and NOx measurements for the three fuels. See Table 4.

Particulate emissions for the three fuels were small and exhibited nearly identical values when compared with and without the Additive. In fact, for all three fuels, average particulate emission measurements with the Additive were less than or equal to those obtained without the Additive. The average particulate emissions for the three fuels are tabulated on the following page:

AVERAGE PARTICULATE EMISSIONS - FTP CYCLE
SwRI - 3.0L Chrysler LeBaron

gm/mile

Fuel	With HiTEC 3000	Without HiTEC 3000	Diff.[1]
Howell EEE	0.008	0.009	-0.001
Texaco Premium	0.008	0.008	0.0
Sun Cert.	0.005	0.013	-0.008

[1]Difference is "With HiTEC 3000" minus "Without HiTEC 3000".

Particulate emission data for all fuels are shown in Table 4.

IV. CONCLUSIONS

Emission test results from two independent laboratories verify that there is no fuel-specific emission effect with the use of HiTEC 3000 Performance Additive.

Supplier: Sun Marketing and Refining
Quantity: 8600 gallons in Tank #1
Batch: Delivery Order #2 Batch 9007762
Proposed Use('s): Certification Test Fuel

Item	Method	Units	Target	Tested by: Sun / Where: refinery / When: 15-Oct-90	EOD / Truck / 15-Dec-90	EOD / Tank #3 / 15-Dec-90	Core / Tank #3 / 15-Dec-90	OFFICIAL EOD VALUES	In Spec ?
RVP	ASTM D 323	psi	9.0-9.2		9.26	9.19		9.19	Yes
RVP Herzog Digital	ASTM D 4953	psi			9.24	9.20		9.20	
Vapor Pressure Pabs	Grabner	psi			9.43	9.24		9.24	
SwRI	ES-14	psi		9.1					
Distillation	ASTM D 86								
initial boiling point		°F	75-95	88	94.1	92.4		92.4	Yes
5% evaporated		°F			110.1	107.0		107.0	
10% evaporated		°F	120-135	133	129.0	124.5		124.5	Yes
20% evaporated		°F			161.6	138.3		138.3	
30% evaporated		°F			190.4	148.8		148.8	
40% evaporated		°F			211.2	157.1		157.1	
50% evaporated		°F	200-230	222	222.6	210.7		210.7	Yes
60% evaporated		°F			231.4	231.8		231.8	
70% evaporated		°F			240.2	244.4		244.4	
80% evaporated		°F			254.4	269.7		269.7	
90% evaporated		°F	300-325	305	298.4	313.7		313.7	Yes
95% evaporated		°F			336.9	330.0		330.0	
end point		°F	415 MAX.	393	399.2	374.3		374.3	Yes
evaporated at 160 °F		Vol %			19.5	19.3		19.3	
Sulfur	ASTM D 1266	wt%	0.01 MAX.	0.01			0.0051	0.0051	Yes
Lead	ASTM D 3237	g/gal	0.05 MAX.	<0.005		<0.005		<0.005	Yes
Manganese	AA	g/gal	_						
Phosphorous	ASTM D 3231	g/gal	0.005 MAX.	<0.005			<0.0001	<0.0001	Yes
Water (Wt%)	Karl Fische	Wt %	_						
Hydrocarbon Compositio	ASTM D 1319								
olefins		Vol %	10 MAX.	6.3		4.60		4.60	Yes
aromatics		Vol %	35 MAX.	25.5		25.90		25.90	Yes
saturates		Vol %	REMAINDER	68.2		69.50		69.50	Yes
Research octane number	ASTM D 2699		96.0 MIN.	97.3			96.6	96.6	Yes
Motor octane number	ASTM D 2700		_	88.5			86.6	86.6	
Antiknock index	ASTM D 439		_	92.9			91.6	91.6	
Sensitivity	RON-MON		7.5 MIN.	8.8			10.0	10.0	Yes
Weight fraction carbon	ASTM D 2789		_						
Weight fraction carbon	ASTM E 191		_						
Weight fraction carbon	ASTM D 3343		_	0.8630779		0.8633675		0.8633675	
Net heat of combustion	ASTM D 240	BTU/lb	_						
Net heat of combustion	ASTM D 3338	BTU/lb	_	18528.015		18519.350		18519.350	
API Gravity	ASTM D 1289	°API	_	59.9	60.1	60.1	60.0	60.1	Yes
Specific gravity (60°F/60°F)			_	0.7392894	0.7385177	0.7385177	0.7389034	0.7385177	
Fuel economy numerator (g carbon/gal)			2401-2441	2411		2409		2409	Yes
				2412		2412		2412	

Table 1

Table. 1A

	Certification Fuel Specifications Min Max	(1) Howell EEE	(2) Phillips Cert Fuel "Indolene"	(3) Sun Cert Fuel "Indolene"	(4) Toyota Cert	(5) Sun Cert Fuel "Indolene"	(6) Texaco Premium
Gravity, API		59.2	58.6	59.8			59.2
Reid Vapor Pressure, psi	9.0-9.2	9.2	9.1	9.1	9.9	8.6	
Sulfur, Wt%	.01 max	.001	.0036	.0056		.0054	.012
Lead, gm/gallon	.05 max	.001	.004	<.005		.003	.001
Phosphorus, gm/gallon	.005 max	Nil	Nil	Nil		Nil	
Research Octane NR	96 min	96.5	96.6	97.2	91.4	97.5	96.5
Hydrocarbon Composition							
Olefins, Vol%	10 max	1.8	2.6	5.7	6.8	2.3	1.4
Aromatics, Vol%	35 max	31.7	31.0	26.8	36.5	24.2	25.5
Saturates, Vol%		66.5	66.4	67.5	56.7	73.5	73.1
Distillation, °F							
Initial Boiling Point	75-95	92	88	83	85	80	86
10%	120-135	128	123	130	119	133	125
50%	200-230	218	223	225	211	225	225
90%	300-325	313	306	303	343	301	340
End Point	415 max	373	404	404	402	412	411
Oxygenates %							
MTBE	None	Nil	Nil	Nil	Nil	Nil	0.1
Ethanol	None	Nil	Nil	Nil	Nil	Nil	0.1
Methanol	None	Nil	Nil	Nil	Nil	Nil	0.1

Notes:

(1) Ethyl Test Fuel
(2) EPA (Ann Arbor) Test Fuel, August-October 1990
(3) EPA (Ann Arbor) Test Fuel, March-May 1991
(4) Toyota Test Fuel (Toyota letter to EPA, dated 1 March 1991). Toyota particulate emissions with and without MMT were exceedingly low. HC increase reported of 0.1 gm/mile at 30,000 miles, but standard not exceeded.
(5) Indolene (Batch 1) provided Ethyl by EPA for comparison testing. Composition inspection made 23 May 1991.
(6) Used in SWRI tests May-June 1991.

Table 2

EMISSION TEST RESULTS – ECS LABORATORIES

1990 5.0L Ford Crown Victoria

FTP CYCLE

Date	Fuel	Emission, g/mi		
		HC	CO	NOx
5/23/91	EEE	0.28	1.18	0.69
5/24/91	EEE	0.27	1.47	0.62
5/29/91	H3	0.26	1.29	0.62
5/30/91	H3	0.22	0.64	0.62
5/31/91	EEE	0.23	1.28	0.69
6/01/91	EEE	0.25	0.93	0.78
6/04/91	SUNC	0.23	0.90	0.66
6/05/91	SUNC	0.24	0.71	0.66
6/06/91	SUH3	0.23	0.79	0.70
6/07/91	SUH3	0.21	0.58	0.73
6/10/91	SUH3	0.23	0.84	0.71
6/11/91	SUH3	0.22	1.00	0.71
6/12/91	SUH3	0.22	0.72	0.76

1988 2.5L Buick Century – Car G–6

FTP CYCLE

Date	Fuel	Emission, g/mi		
		HC	CO	NOx
6/05/91	H3	0.163	1.64	0.33
6/06/91	SUNC	0.165	1.86	0.34
6/10/91	SUH3	0.176	2.14	0.35
6/11/91	SUH3	0.183	1.81	0.30
6/12/91	SUNC	0.182	1.95	0.34

Note – H3 is Howell EEE plus HiTEC 3000.
EEE is Howell EEE.
SUH3 is Sun certification plus HiTEC 3000.
SUNC is Sun certification fuel.

LABORATORY INSPECTION DATA

Table 3

Texaco Premium – SwRI

API Gravity	59.2
Specific Gravity	0.742
ASTM Distillation, F	
IBP	86
5%	105
10%	125
15%	140
20%	155
30%	184
40%	209
50%	225
60%	239
70%	259
80%	299
90%	340
95%	368
EP	411
% Recovered	97
% Residue	1
% Loss	2
FIA Analysis	
Aromatics, %	25.5
Olefins, %	1.4
Saturates, %	73.1
Sulfur, wt%	0.012
Octane Number	
RON	96.5
MON	88.1
Pb, gm/gal	0.001
Oxygenates, %	
MTBE	0.1
Ethanol	0.1
Methanol	0.1

Table 4

EMISSION TEST RESULTS – SOUTHWEST RESEARCH INSTITUTE

1991 Chrysler LeBaron 3.0L V–6
Vin No: 1C3XJ4532MG.106621
Inertia: 3875 HP: 8.1

FTP CYCLE

Driver	Date	Odom.	Fuel	Emission, g/mi HC	CO	NOx	Part.	MPG
DL	5/15/91	10990	H3	0.32	1.67	0.35	0.013	21.02
DL	5/16/91	11046	H3	0.40	1.89	0.49	0.007	21.11
DL	5/17/91	11104	H3	0.40	1.89	0.41	0.006	20.89
DL	5/20/91	11168	H3	0.38	2.09	0.44	0.007	20.98
DL	5/30/91	11254	EEE	0.36	1.83	0.49	0.009	21.06
DL	5/31/91	11294	TPC	0.52	2.42	0.52	0.007	21.34
DL	6/03/91	11305	TPC	0.47	2.30	0.47	0.008	20.98
RG	6/05/91	11348	TPH3	0.46	2.49	0.47	0.007	21.71
RG	6/06/91	11359	TPH3	0.46	2.42	0.44	0.007	21.01
DL	6/07/91	11371	TPH3	0.46	2.14	0.41	0.008	21.79
DL	6/10/91	11640	TPH3	0.42	2.25	0.47	0.010	22.23
DL	6/11/91	11679	SUH3	0.31	1.76	0.59	0.007	21.45
DL	6/12/91	11690	SUH3	0.32	1.79	0.45	0.003	21.66
DL	6/14/91	11961	SUH3	0.39	2.02	0.49	0.006	21.67
DL	6/17/91	11995	SUNC	0.32	2.05	0.57	0.006	21.71
DL	6/18/91	12006	SUNC	0.38	2.09	0.55	0.020	21.82

Note – H3 is Howell EEE plus HiTEC 3000.
EEE is Howell EEE.
TPC is Texaco Premium.
TPH3 is Texaco Premium plus HiTEC 3000.
SUH3 is Sun certification plus HiTEC 3000.
SUNC is Sun certification fuel.

AN INVESTIGATION OF THE EFFECTS OF HiTEC 3000 ON PARTICULATE EMISSIONS

INTRODUCTION

As part of a waiver application filed by Ethyl Corporation ("Ethyl") on May 9, 1990 for use of HiTEC® 3000 Performance Additive ("HiTEC 3000") in unleaded gasoline, Ethyl had the ECS Laboratory in Livonia, Michigan ("ECS") measure particulate emissions from eighteen of Ethyl's 48-car test fleet -- nine cars operated about 75,000 miles on clear Howell EEE gasoline and nine cars with similar mileage operated on Howell EEE with 0.03125 grams of manganese/gallon. These results were reported in the original waiver application in Appendix 3, Attachment 3-23.

As part of its review of Ethyl's waiver application, EPA instructed its Ann Arbor laboratory to test several leased cars from the U. S. and Canada, as well as six cars from Ethyl's test fleet. EPA's particulate test results for cars operated on clear fuel were similar to results obtained on Ethyl's fleet test cars at the ECS laboratory. However, EPA's particulate results for cars using fuel containing HiTEC 3000 were higher than the same cars operated on similar fuel at ECS. (Attachment 1)

This appendix provides the results of additional particulate testing conducted by Southwest Research Institute ("SwRI") in San Antonio, Texas as part of an effort designed to explain differences in test results at the EPA and ECS laboratories. The results of this additional testing show that the use of HiTEC 3000 in unleaded gasoline will not have a material impact on particulate emissions.

BACKGROUND

An initial investigation of the equipment and protocol used by the EPA and ECS laboratories disclosed differences that could have a major effect on test results. Both laboratories used the Federal Test Procedure that is designed to determine emissions from diesel engines (See 40 C.F.R. 86.110-86.112), because there is no approved Federal test procedure for particulates from gasoline powered vehicles.[1] The modifications to the diesel particulate procedure, made by EPA and ECS, resulted in differences in tunnel diameter, dilution air flow rate, sample flow rate and preparation of the equipment. For

---

1 EPA proposed a test procedure for measuring particulate emissions from gasoline powered vehicles at 56 Federal Register 9754 (March 7, 1991).

example, at ECS the tunnel was cleaned and a new connector was installed before the tests on gasoline engines were begun. This removed deposits that had accumulated from previous tests on diesel engines. EPA, by contrast, had allowed similar pieces of equipment used in the laboratory to accumulate diesel-related particulate deposits. In discussions with EPA during November, 1990, they reported that the tunnel and connector had not been cleaned for several years.

The major differences in equipment design and test protocol are outlined in the table below.

TABLE 1

DIFFERENCES IN EQUIPMENT AND PROTOCOL FOR PARTICULATE TESTS

	ECS	EPA
Tunnel diameter	18 inches	10 inches
Connecting pipe	Flexible, corrugated, uninsulated	Rigid, smooth, insulated
Sample flow rate	1.8 SCFM	1.0 SCFM
Filters	One set/Bag	One set/3 Bags
Sample probe inlet	37 mm at inlet, reduced to 0.5" O.D. tubing	5/8" O.D., constant size
Test cycles	FTP only	FTP, HFET, NYC

Following this initial investigation, EPA and Ethyl held several meetings. The objectives were to first, describe the known differences in test protocol, and second, to agree on a project that would evaluate the significance of the differences. As a result of the meetings:

1. Ethyl contracted with Southwest Research Institute (SwRI) to build a tunnel and the connecting pipe from the vehicle to the tunnel to conform exactly to EPA's specifications. EPA provided drawings of their equipment to Ethyl.

2. The air flow rate in the new tunnel would be the same as in EPA's tunnel.

3. The tunnel at SwRI would have multiple sample probes so that test parameters -- sample flow rate and number of filters used per test -- could be varied. This consisted of a removable array of six probes with the same dimensions as EPA's, plus one separately mounted probe to exactly duplicate EPA's probe.

4. A 20 inch x 20 inch total filter would be mounted at the end of the tunnel to crosscheck the effectiveness of the probe samplers. (This was an added feature that was not present at either EPA or ECS laboratories.)

5. An experimental instrument, a Tapered Element Oscillating Microbalance (TEOM) would be evaluated as a means to directly measure particulates.

SwRI constructed the tunnel and associated equipment after EPA had reviewed the drawings and had not recommended any changes.

The approved design enabled SwRI to collect particulate emissions under a variety of conditions. Specifically, the effects of sample flow rate (1.7 vs 1.0 SCFM)[2], and the number of filter sets used per test (one set/Bag vs one set/3 Bags) could be investigated. Also, the effect that probe design had on results (a single separately mounted probe rather than multiple removable probes) could be evaluated.

However, the size and configuration of the tunnel and connecting tube, and the dilution air flow rate, were fixed to duplicate conditions at EPA's laboratory. While this eliminated any opportunity to see whether those variables affected test results on particulates, evaluating them was not deemed critical to this project.

Throughout the joint project, there was excellent cooperation between SwRI, EPA and Ethyl. This made it possible to investigate the effects various parameters in the protocol had on test results.

SwRI TEST PROTOCOL

It was important that sufficient data be gathered in this project on particulates so that proper statistical analyses could be performed. This meant that several cars had to be tested within a broad matrix of conditions.

The cars chosen for the tests included both low mileage leased cars and high mileage Ethyl fleet test cars.

1. 1991 GM Chevrolet Lumina, 3.1L V-6 engine. Fuel history: commercial clear fuel only, leased, 9,113 miles.

2. 1990 Ford Crown Victoria, 5.0L V-8 engine. Fuel history: commercial clear fuel only, leased, 15,168 miles.

----

2 ECS used a flow rate of 1.8 SCFM, the highest flow rate that they could obtain with their equipment. The maximum flow rate that could be obtained at SwRI was 1.7 SCFM.

3. 1991 Chrysler LeBaron, 3.0L V-6 engine. Fuel history: commercial clear fuel only, leased, 9,437 miles.

4. 1988 GM Chevrolet Cavalier, 2.0L 4-cyl. Fuel history: clear Howell EEE only, 75,116 miles, Ethyl test fleet.

5. 1988 GM Chevrolet Cavalier, 2.0L 4-cyl. Fuel history: Howell EEE plus HiTEC 3000, 75,117 miles, Ethyl test fleet.

6. 1988 GM Buick Century, 3.8L V-8. Fuel history: clear Howell EEE only, 75,107 miles, Ethyl test fleet.

7. 1988 GM Buick Century, 3.8L V-8. Fuel history: Howell EEE plus HiTEC 3000, 75,164 miles, Ethyl test fleet.

The testing matrix is shown in Attachment 2, with the test protocol in Attachment 3. Briefly, the test matrix was designed to provide replicate data from each of the test cars.

EPA reviewed both the testing matrix and test protocol before the testing was begun. Additionally, an EPA representative inspected the tunnel and probe assemblies while the tunnel was out of service and again while SwRI was running a test. He did not recommend changes or offer suggestions for improvements.

TEST RESULTS

The data collected by SwRI, and an analysis of the data, are reported in Attachment 4.

SwRI was unable to get useful data with the experimental Tapered Element Oscillating Microbalance. Consequently, test results from the TEOM were not evaluated in this appendix.

Table 2 below summarizes the test results on particulate emissions for the leased cars and Ethyl's fleet cars.

In addition to determining the weight of particulates, SwRI collected data on fuel economy for each of the test vehicles. With this information, and the analysis of the particulates for manganese content by Ethyl's Baton Rouge, Louisiana R & D laboratory, Ethyl calculated the percent of manganese in the fuel that was emitted from the tailpipe.

The manganese on the filters represented from 7% to 12% of the manganese in the fuel that was consumed during the various test cycles. The FTP cycle, which is designed to represent typical driving patterns, was 11%. This is well below the value of 30% that Ethyl and others have used to estimate how use of HiTEC 3000 would affect ambient manganese levels.

TABLE 2

AVERAGE PARTICULATE EMISSIONS
Sample 4, Filter Position #5 (1)

	All Test Cars g/Mile FTP Cycle
Howell EEE + HiTEC 3000 (2)	0.007
Howell EEE	0.005
Manganese from Fuel Consumed, %	11.2
	Highway Fuel Economy Cycle
Howell EEE + HiTEC 3000 (2)	0.015
Howell EEE	0.012
Manganese from Fuel Consumed, %	7.2
	New York City Cycle
Howell EEE + HiTEC 3000 (2)	0.011
Howell EEE	0.007
Manganese from Fuel Consumed, %	11.7

(1) Same configuration as at EPA's laboratory in Ann Arbor (Attachment 2).

(2) 0.03125 gr Mn/Gallon as HiTEC 3000.

These data from SwRI showed that the level of particulates in the exhaust from cars using either clear fuel or fuel containing HiTEC 3000 were extremely low. Indeed, the differences for total particulates quoted above in Table 2 are, if anything, too high. See Attachment 4 at 4-5. These results were similar to the data obtained earlier by ECS. Therefore, the higher level of particulates reported by EPA's Ann Arbor laboratory apparently came from a source other than HiTEC 3000.

Because these tests did not explain the difference in the quantity of particulates emitted from the vehicles, the chemical composition of the particulates was determined in order to provide more information on their source.

CHEMICAL ANALYSIS OF PARTICULATES

The EPA and SwRI laboratories each collected particulates for analysis. EPA loaded two pairs of filters according to the conditions outlined in the letter from Martin Reineman to I. L. Smith, which is included in Attachment 5. SwRI loaded filters from all sample points listed in Attachment 2, with both clear fuel and fuel containing HiTEC 3000. Filters from Sample 4, (Filter Position # 5) which duplicated conditions at the EPA laboratory, were analyzed at Ethyl's Research and Development Laboratory in Baton Rouge, Louisiana. The chemical composition of the particulates on these filters was determined according to the procedure described in Attachment 5. [Memo from I. L. Smith to Dr. G. L. Ter Haar, 3/21/91]. (The other filters from SwRI were not analyzed because they were collected under different conditions than those from EPA.) Results of the chemical analyses are shown in Table 4.

TABLE 4

CHEMICAL COMPOSITION OF PARTICULATES

Source Vehicle	EPA Chevrolet Caprice	SwRI Ford Crown Victoria	SwRI Ford Crown Victoria	SwRI Chevrolet Cavalier	SwRI Chevrolet Cavalier
Fuel	HiTEC 3000	HiTEC 3000	Clear	HiTEC 3000	Clear
	Concentrations in mg/Mile				
Manganese	0.098	0.064	0.009	0.08	0.002
Iron	0.49	0.021	0.014	0.12	0.16
Zinc	3.1	0.036	0.009	0.67	0.30
Calcium	2.0	0.018	0.013	0.24	0.10
Barium	4.9	0.028	<0.02	0.89	0.35
Chloride	26.5	0.008	0.003	0.15	0.19
Sulfate	0.22	3.6	3.9	0.07	0.05
Total	37.3	3.78	3.95	2.22	1.15
Manganese and Sulfur as percent of the material from fuel consumed					
Manganese, %	6.4	5.1	----	8.2	---
Sulfate, %	1.5	13.4	14.6	0.3	0.2

The composition of the material collected on the filters at EPA's Ann Arbor laboratory differed substantially from the material on the SwRI filters. The EPA filters had higher concentrations of calcium and zinc, which could be from additives present in gasoline and diesel engine lube oils. More significantly, the EPA filter contained substantial quantities of barium, which is not present in lube oils or gasoline. However, organic compounds containing barium have been used as combustion catalysts and deposit modifiers in diesel fuel.[3] Thus, diesel fuel may have been the source of the barium that EPA reported as particulates from the gasoline engines they tested.

The amount of chlorides and sulfates that were recovered on the filters also was different. The source of chlorides on the EPA filters is unknown. Chlorides are not present in gasoline, so they should not be found at high concentrations in particulates from gasoline engines. The reason for the difference between the EPA and SwRI laboratories in recovered sulfates was not determined in this program.

CONCLUSIONS

The results of the particulate testing at SwRI demonstrate that use of the Additive in unleaded gasoline will not materially increase particulate emissions. In addition, the SwRI test results further confirm that manganese tailpipe emissions associated with the use of the Additive are in the 10 to 15 percent range.

Finally, the SwRI test results, together with the results of the particulate analyses completed by Ethyl's research laboratory in Baton Rouge, suggest that the relatively high particulate measurements obtained by EPA in its August-October 1990 testing may be the result of materials from sources (eg., chlorides) unrelated to HiTEC 3000. These results are not inconsistent with the increase in particulates being associated with prior use of the EPA tunnel to measure diesel engine emissions.

---

3 Fuels and Lubricants Primer for Automotive Engineers, SAE SP-671, "Gasoline and Diesel Fuel Additives for Performance/Distribution Quality", pages 92 and 93.

Attachment 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

October 29, 1990

OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: MMT Testing Program Report

FROM: J. Bruce Kolowich, Manager
Fuels and Chemistry Services

TO: Mary Smith, Director
Field Operations & Support Division

THRU: Richard D. Lawrence, Director
Engineering Operations Division

Attached is the complete description and summary of the testing program to determine the effects of MMT on exhaust emissions.

Attachment

DEC - 5 1990

Studies on the Effects of MMT Use on Vehicle Emissions

1.0 INTRODUCTION

Ethyl Corporation submitted a recent fuel additive waiver application to the Environmental Protection Agency, proposing the nationwide use of methylcyclopentadienyl manganese tricarbonyl (MMT) as an octane enhancer in unleaded motor vehicle fuel. In previous applications, Ethyl Corp. had made similar requests, and response from the agency had centered on the need for a comprehensive test program before any waiver involving the use of MMT could be granted. As a result, this most recent waiver application contained the results of a major study intended to confirm the hypothesis that MMT use at 1/32 g(Mn)/gal caused no ill effect to the emission control systems of current automobiles. (See EPA AIR Docket A-90-16)

Among the conclusions presented with the study were the theories that MMT use contributed to a lessening in the amount of nitrogen oxides, carbon monoxide, and total particulate emitted over the life of the vehicle (when compared to an identical vehicle who's fuel contained no MMT), and that manganese emission was limited to, on average, 0.4% of the amount introduced to the engine. One further result of the study stated that increased hydrocarbon emission, a problem with MMT use in earlier studies, was limited to 4% relative to the applicable hydrocarbon standard. This work was originally undertaken in an attempt to confirm some aspects of the Ethyl submission, especially with respect to manganese emissions.

The waiver process allows the agency 180 days from date of receipt of the waiver application to reach a decision on the waiver. The last day for a decision on this waiver application is November 5, 1990. Testing and technical support from EOD was requested on July 27, 1990. The test program commenced immediately and was completed on October 19, 1990. Due to the limited time available the focus of the program was to address unresolved technical questions which were surfacing while reviewing the waiver application.

1.1 Testing and Mileage Accumulation Fuels

All vehicle tests were run using Phillips 96 RON Certification Gasoline. Additionally, all tests completed during the investigation used fuel from the same batch of Phillips Unleaded Test Gasoline (UTG). The measured parameters for this batch of UTG are included in Attachment A. When tests were carried out with UTG containing no MMT, these vehicles were fueled directly from the dispensers normally used for certification testing. These dispensers maintain the fuel at or near 45°F. When MMT containing fuel was used for testing, the fuel was maintained at or near this temperature by virtue of its storage in a fuel conditioning cart. Only one cart was used for all MMT containing test fuel. In preparing the MMT containing test fuel, the cart was first filled to near capacity with UTG from the dispenser, and the appropriate amount of MMT was added. The fuel was allowed to mix in the cart for between 20 and 60 minutes, and a sample was removed for manganese analysis. In all cases, manganese concentration was verified to be between 0.029 and 0.033 g(Mn)/gal° before any test was commenced with the fuel. The cart used for containing this fuel was a Horiba model 073 FCT, and contained its own internal refrigeration system. As a precaution, one test was run with fuel from the cart before the addition of HITEC to verify that non-MMT fuel from the cart gave results consistent with those of fuel directly from the dispenser.

A second base fuel was procured for the purpose of mileage accumulation. This fuel was a Gulf commercial regular gasoline. The pertinent measured parameters for this gasoline, both before and after MMT addition, are shown in Attachment B. One thousand gallons of this fuel was placed in an underground storage tank, and the appropriate amount of MMT added. The fuel was mixed overnight with the tank's internal pump, and a sample of the fuel was analyzed for manganese content before any mileage accumulation was begun.

1.1.1 MMT Sources

Two sources of MMT were used during the course of the program. The initial source of MMT was an over-the-counter commercial additive. Manganese analysis of this product was consistent with the propriatary analysis supplied by the manufacturer. This was the source of MMT for the Gulf commercial regular gasoline used in initial mileage accumulation, as well as the source for early testing. The last tests using the commercial additive as the source for MMT in this program were run on 9/6/90.

On September 6, 1990, Ethyl Corp. visited the EPA Motor Vehicle Emission Laboratory (MVEL) in Ann Arbor, MI for the purpose of delivering a sample of their MMT, known commercially as HITEC 3000. Agents of the Ethyl Corporation witnessed and aided in the blending of the initial batch of fuel containing HITEC 3000, to be used for testing at (MVEL). All testing performed subsequent to this date used only HITEC 3000 as an MMT source. A sample of this initial batch of fuel was given to Ethyl for their parallel analysis.**

1.2 Vehicle Selection and Procurement

1.2.1 American Vehicles

A total of six American vehicles were acquired for testing pur-oses. All of these were procured on short term lease arrangements

° 1/32 g/gal=.03125 g/gal

**/ Ethyl Explanatory Note: While Ethyl personnel were present for the blending that took place at the EPA Ann Arbor laboratory prior to the August-October 1990 tests, the blending was performed by EPA personnel and equipment. Furthermore, while a sample of the blended fuel was made available to Ethyl for analysis, Ethyl had no reason at that time to analyze the fuel for anything other than manganese content, as opposed to potential "contaminants" introduced into the test fuel as a part of the Ann Arbor blending process.

through EPA's on site contractor, E G & G automotive research. As an approximation, these vehicles were acquired in pairs as the testing program grew. The two initial vehicles were a 1990 Ford Taurus, Veh #8888, and a 1990 Chevrolet Cavalier, Veh #0099. These models were selected due to their availability, and the fact that similar models were included in Ethyl's testing program. When initially procured, these vehicles had relatively low mileage, Veh #8888 began with 3883 miles, and Veh #0099 with 2160 miles.

The third and fourth vehicles were acquired approximately three and five weeks into the program. An additional Cavalier, Veh #0077, was acquired after three weeks for the purpose of repeating the testing on Veh #0099 for comparison. Most of the testing on Veh #0099 was performed with the commercial additive as the MMT source, but all tests on Veh #0077 were performed with HITEC 3000 as the MMT source. An additional Taurus, Veh #0024, was acquired after five weeks to serve as a pseudo-control vehicle for comparison to Veh #8888. When acquired, Veh #0024 had 11,508 miles accumulated, compared with the 11,912 miles accumulated on Veh #8888 just prior to its final testing sequence.

The final pair of American vehicles were acquired September 24, 1990, as an effort to diversify the testing fleet. These two models included a 1991 Pontiac Sunbird, Veh #0041, acquired with 4170 miles, and a 1991 Dodge Dynasty, Veh #0051, with 2126 miles. Both vehicles were subjected to testing with clear UTG and with UTG containing 1/32 g(Mn)/gal HITEC 3000.

1.2.2 Canadian Vehicles

Three Canadian vehicles were obtained on short term lease for testing. The use of MMT has been permitted in Canada since 1986 at levels of 1/16 g(Mn)/gal (0.062 g(Mn)/gal) and below. Since within the time frame of this program it was impossible to accumulate mileage at levels comparable to the Ethyl study, the use of Canadian vehicles was an attempt to simulate the use of MMT for high mileage.

The first of these vehicles was a Chevrolet Corsica, Veh #0011, acquired with 24,338 kilometers accumulated. One testing sequence on each MMT source (the commercial additive and HITEC) was completed. This vehicle was selected because it was of the same engine family as Vehicles #0099 and #0077. The second Canadian vehicle was a GMC 3/4 ton van. This light duty truck, Veh #0021, was tested twice on the commercial additive, and twice on HITEC 3000, with a single testing sequence on UTG in between. The truck was acquired with 53,522 kilometers accumulated. These two vehicles were specifically acquired from rental agencies in the London and Hamilton, Ontario areas respectively, as it was felt that procurement from the interior of Canada would insure that very little of the mileage accumulated on them would have resulted from (MMT free) U.S. fuel.

The third Canadian vehicle was also a light duty truck. This vehicle, #0031, was a Chevrolet 1/2 ton van, acquired from Windsor, Ontario with 13,384 kilometers accumulated. This vehicle was tested twice, both with HITEC 3000. Since it was acquired from a rental agency so near the U. S./Canadian border, there was less confidence that all of the accumulated mileage was on MMT containing fuel; however, the fuel in the vehicle was analyzed upon its receipt at the MVEL, and was found to contain 0.048 g(Mn)/gal.

1.2.3 Ethyl Test Vehicles

Following the bulk of the testing of the first nine vehicles, Ethyl was approached about the possibility of testing two or three pairs of the cars from Ethyl's testing fleet at the EPA MVEL in Ann Arbor, MI. Representatives from Ethyl agreed to allow EPA to perform the testing, and three sets of paired vehicles were driven from the ECS testing labs in Livonia, Michigan to MVEL. All of these vehicles were 1988 model year, and were identified as Ethyl test vehicles G1 (non-MMT) and G5 (MMT), both Buick Centuries with 2.5l 4 cylinder engines; H2 (non-MMT) and H4 (MMT), both Buick Centuries with 2.8l V6 engines; and F5 (non-MMT) and F3 (MMT), both 1988 Ford Crown Victorias with 5.0l V8 engines. All non-MMT cars were tested on UTG, while the MMT cars were tested with UTG containing HITEC/3000 at the level of 0.031 g(Mn)/gal. All of these MMT vehicles received a final test with clear UTG. In some cases, the MMT vehicles received a second test on MMT fuel.

1.3 Mileage Accumulation Route

The route selected for mileage accumulation was 124 miles long and typically required three hours for completion, yielding an average speed of 40 miles per hour. The route was designed to include sections of travel at all common speeds. A chart illustrating the speed distribution for the route is contained in Attachment C. This chart was compiled from time and distance data taken from vehicle log books.

The directions supplied to the mileage accumulation drivers were as follows:

Leaving MVEL, turn left (East) on Plymouth Road.
From Plymouth Road, enter US-23 south.
From US-23 South, enter I-94 East.
Exit I-94 east at Cadieux, turn right at Cadieux.
From Cadieux, turn left on Jefferson Avenue.
From Jefferson Avenue, turn left on Nine Mile Road.
From Nine Mile Road, turn left on Middlebelt.
From Middlebelt, turn right on Eight Mile Road.
From Eight Mile Road, turn left on the Pontiac Trail.
From the Pontiac Trail, turn left on Plymouth Road.
From Plymouth Road, turn left into the MVEL.

All initial mileage accumulation was completed on vehicles #8888 and #0077 with Gulf commercial regular gasoline containing MMT from the commercial additive. Any mileage accumulated on Veh #0077 was completed using UTG containing MMT in the amount of 0.031 g(Mn)/gal. Mileage accumulated on any other vehicle was accomplished using one of these fuel mixtures. Those miles accumulated before September 6, 1990 used the first fuel mixture described, those after September 6 were acquired with the latter.

1.4 Analysis of Manganese in Fuel

The elemental analysis of Manganese in fuel was performed via the technique of X-ray Fluorescence Spectrometry (XRF). In all cases, samples were acquired as short term composites from nozzle streams. Samples were taken in four ounce french square bottles, and allowed to warm to room temperature before analysis.

The actual procedure was identical in all respects but two to the CFR procedure for analysis of lead in fuel. The two deviations are obvious; standard samples were prepared with the use of a commercial manganese in oil sample as the primary standard, and the XRF instrument was tuned to the appropriate emission line for manganese. In all cases of fuel for testing, samples were taken in duplicate, and both were analyzed. As was previously stated, if the analytical results indicated that the concentration of manganese in the test fuel was outside the limits of 0.029 to 0.033 g(Mn)/gal, the fuel was reblended to adjust its manganese level.

2.0 The Testing Site

All tests for the program were performed using the same dynamometer and analysis bench, MVEL Dyno 7. Testing is performed on a Clayton Hydrokinetic chassis dynamometer Model #ECE-50. As the vehicle is operated on the dynamometer, the exhaust gases are collected and diluted with a Horiba Constant Velocity Sampler (CVS) Model 20 and a small sample is retained in Tedlar bags. For all tests performed during this program, the CVS flow rate was set to 350 SCFM. The retained samples are analyzed using a Horiba Model AIA-23 NDIR analyzer for CO & CO2 analysis, a Beckman Model 951A NOx analyzer for nitrogen oxide analysis, and a Beckman Model 400 FID for hydrocarbon analysis.

Particulate measurements were completed using the standard CFR test procedure for diesel particulate testing, with one deviation. In traditional diesel testing, one filter pair is employed for each bag sample, but in the MMT testing program one filter pair was employed for the entire test. This change was instituted to increase the detection limit of the particulate measurement, as the mass increase of the filter elements was presumed to be very small. This change resulted in all FTP particulate results being reported as unweighted values, and was continued throughout the program.

Filters were purchased from Pallflex Products Corp, and were type T60A20, a glass fiber filter of 47 mm diameter. A sample was removed isokinetically from the center of the 10" diameter particulate tunnel during the test. Exhaust gases are conducted to the tunnel through 4" diameter, smooth wall, insulated, stainless steel pipe. Filters were weighed before and after each test using a CAHN model C-30 microbalance on its most sensitive range. The detection limit of this balance is one microgram, and to support this, the balance is contained in a temperature and humidity controlled room. All filters were allowed to equilibrate with the atmosphere in the balance room for several hours prior to any weighing. One operator performed all balance measurements.

2.1 Exhaust Manganese Analysis

Two types of manganese emission were deemed possible, those being emission as particulate or as a vapor phase. Vapor phase emission was unlikely, given the chemistry of Mn(I) compounds, but in the interest of completeness, one test was performed in such a way as to trap any volatile manganese compounds that might be emitted.

2.1.1 Analysis for Volatile Manganese

To trap any volatile compounds that may be emitted, a liquid nitrogen trap was placed immediately behind the particulate filter during a test in which the vehicle, a 1990 Ford Crown Victoria was fueled with a high concentration (1/8 g(Mn)/gal) of MMT. Normally, the sample passing through the filter would proceed directly to the dry gas meter, but for this one test, the flow was diverted into the cryogenic trap. After the completion of one LA-4 cycle, the trap was removed from the system, and its interior rinsed with hydrochloric acid (HCl). This acid was analyzed for manganese content. Since no manganese was found, it was concluded that any manganese emission must be in the form of a particulate.

2.1.2 Analysis for Airborn Manganese Emission

Analysis for manganese emitted as particulate was accomplished by acid hydrolysis of the filter elements. Each filter was placed in a clean 125 ml Erlenmeyer flask, and 3 ml of 37% HCl was added. The flask containing the filter and the acid was heated to near boiling for 30 minutes. At the end of this period, the flask was removed from the heat, and the liquid decanted from it. The filter and flask were rinsed with several small portions of water to bring the total of the washings plus acid to 20 ml. These 20 ml liquid samples were analyzed via atomic absorbance spectrometry for manganese content.

A Perkin Elmer model 306 Atomic Absorption Spectometer was used for these analyses. Since this is a single beam instrument without background correction, several precautions had to be taken to insure that any measured absorbance was due to manganese in solution, and not to some matrix effect. To alleviate the concerns of absorbance from background, all samples were filtered prior to analysis, and several samples were spiked with manganese to measure the recovery. To compensate for the single beam nature of the instrument, blank readings were taken before and after each sample reading, and standard samples were read at the beginning, end, and with each page of analysis. Standard samples were prepared with 99.9999% pure manganese (II) nitrate. Check samples were prepared with Primary Standard quality Potassium Permanganate. A commercial sample of Manganese Tetroxide was used as a check sample to evaluate the digestion process, and a sample of manganous (II) chloride was prepared from the tetroxide, to verify the purity of the tetroxide.

Recovery from all spiked samples was adequate to dispel any concerns of matrix effects. Concentration measurements of manganous (II) nitrate, potassium permanganate, and manganous (II) chloride compared favorably. Results of tetroxide analysis indicated it to be of questional purity, with values ranging from 94% to 97%. Since mixed valence metal oxides are typically difficult to obtain in high purity, these results were taken as acceptable.

2.1.3 Analysis for Manganese Compound Type

Two of the parameters of interest in metal based particulate emission are particle size and oxidation state. Samples of the emitted particulate were recovered from testing filters and catalysts that had been exposed to manganese. Both samples were placed in an analytical electron microscope, JEOL model 2000FX, for particle size measurement, and were also analyzed via Electron Spectroscopy for Chemical Analysis (ESCA) with a Perkin Elmer Phi series model 5400 spectrometer to determine the oxidation state of the manganese compound emitted. These analyses were performed at the X-ray and Electron Microscopy laboratories of the University of Michigan college of Engineering.

2.2 Testing Sequence

All vehicle tests followed the same sequence, in that three different driving cycles were administered. These three cycles, the FTP, the HFET or highway cycle, and the NYCC or New York City Cycle were always performed in this same order. Only one change was instituted during the course of testing. The number of highway cycles was allowed to vary when it became clear that additional distance would be required to improve the significance of the manganese analysis for this cycle. After this change was instituted, any even number of highway cycles might be performed, up to a limit of six, or until the filter elements began to load to the point of restricting flow.

These three cycles were chosen to allow comparisons to be made of emissions in different types of driving conditions. The critical parameters in particulate emissions were expected to be average speed, exhaust volume, and exhaust volume change. In this regard, the FTP is a cycle with numerous starts and stops, and average speed of about 20 MPH. By contrast the HFET has only one start and one stop, but average speed of about 48 MPH. The NYCC has many starts and stops, many long idle periods, and an average speed of about 14 MPH.

3.0 Results of Regulated and Unregulated Emissions Tests

A total of 165 tests were run during the course of the program. Due to the large number of tests, as well as the quantity of vehicles, results were compiled on spread sheets. Final copies of these spread sheets, arranged by the date of the initial test of each vehicle, appear in Attachment D. Each page of this attachment contains data from an individual vehicle. EPA assigned vehicle identification number appears near the top left corner of each sheet. The vehicles are described and correlated with these numbers in section 1.2 above.

Results of the manganese analyses are presented in the tables listed in Attachment D as "per-cent manganese emitted". In those cases where no manganese was input to the vehicle, the calculated result presented in the table assumes that there was 31 mg/gal Mn input to the vehicle, even though this was not the case. These numbers are presented in this fashion to allow a comparison to the tests where manganese was input to the vehicle.

Results of the microscopic analysis of the manganese containing deposition yielded a particle size range of 0.1 to 0.5 microns. This range represents the mass deposited on the filter element from the tunnel sample. Particle size is not relevant in microscopic inspection of the catalysts, since the manganese appears to be deposited as a continuous coating.

ESCA results from these two samples were compared to a standard sample of manganese tetroxide. The spectra acquired in all three cases were virtually identical. The conclusion drawn was that the manganese compound deposited on the catalyst, as well as the manganese compound emitted to the atmosphere, are both manganese tetroxide (Mn_3O_4).

3.1 Quality Control

All dynamometer emissions tests were subjected to the same rigorous data review as certification tests. All inputs are reviewed first on the site, then by computer, and given a final scan by hand. Tests performed on Ethyl vehicles received an additional review by the EPA Correlation Engineering Group of the Engineering Operations Division.

4.0 Summary

Several generalizations are possible from the data collected during the program. Some of the averaged results are summarized below.

A) American Vehicles

a)	Average Total Particulate w/o MMT	0.0075 g/mile
b)	Average Total Particulate w/ MMT	0.0479 g/mile
c)	Average Total Particulate w/ comm'l addit	0.0526 g/mile
d)	Average Total Particulate w/ HITEC	0.0424 g/mile

B) Canadian Vehicles

a)	Average Total Particulate w/ MMT	0.0280 g/mile

C) Ethyl Vehicles

a)	Average FTP HC for non-MMT Cars	0.322 g/mile
b)	Average FTP HC for MMT Cars	0.531 g/mile
c)	Average FTP NOX for non-MMT Cars	0.610 g/mile
d)	Average FTP NOX for MMT Cars	0.408 g/mile
f)	Average FTP CO for non-MMT Cars	2.829 g/mile
g)	Average FTP CO for non-MMT Cars	4.024 g/mile
h)	Particulate Emission from MMT Cars	0.047 g/mile
f)	Particulate Emission after MMT Removal	0.019 g/mile
i)	Particulate Emission of Control Cars	0.011 g/mile
j)	Average FTP Manganese Emission	16.3%

Numerous other such comparisons are possible, as are many direct comparisons to the data presented in the waiver application, but are beyond the intent of this report.

4767c

ENGINEERING OPERATIONS DIVISION
Fuel Analysis Report
Unleaded Test Gasoline (96 RON)

Supplier: Phillips Chemical
Quantity: 5000 gallons

Date delivered: 16-Aug-90
Batch: K-706

Proposed Use('s): Certification Test Fuel

Item	Method	Units	Target	Tested by: EOD Where: Tank #3 When: 17-Aug-90	Core Tank #3 17-Aug-90	OFFICIAL EOD VALUES
RVP	ASTM D 323	psi	9.0-9.2	9.1		9.1
Distillation	ASTM D 86					
initial boiling point		°F	75-95	87.8		88
5% evaporated		°F		108.2		108
10% evaporated		°F	120-135	123.2		123
20% evaporated		°F		148.7		149
30% evaporated		°F		178.8		179
40% evaporated		°F		207.1		207
50% evaporated		°F	200-230	222.6		223
60% evaporated		°F		231.5		232
70% evaporated		°F		243.0		243
80% evaporated		°F		263.8		264
90% evaporated		°F	300-325	305.7		306
95% evaporated		°F		340.1		340
end point		°F	415 MAX.	403.8		404
evaporated at 160 °F		Vol %		23.3		23
Sulfur	ASTM D 1266	wt%	0.01 MAX.		0.0036	0.0036
Lead	ASTM D 3237	g/gal	0.05 MAX.	0.004		0.004
Manganese	AA	g/gal				
Phosphorous	ASTM D 3231	g/gal	0.005 MAX.			<0.0001
Water (Wt%)	Karl Fische	Wt %				
Hydrocarbon Composition	ASTM D 1319			100.0		
olefins		Vol %	10 MAX.	2.6		2.6
aromatics		Vol %	35 MAX.	31.0		31.0
saturates		Vol %	REMAINDER	66.4		66.4
Research octane number	ASTM D 2699		96.0 MIN.		96.6	96.6
Motor octane number	ASTM D 2700				87.6	87.6
Antiknock index	ASTM D 439				92.1	92.1
Sensitivity	RON-MON		7.5 MIN.		9.0	9.0
Weight fraction carbon	ASTM D 2789					
Weight fraction carbon	ASTM E 191					
Weight fraction carbon	ASTM D 3343			0.8658		0.8658
Net heat of combustion	ASTM D 240	BTU/lb				
Net heat of combustion	ASTM D 3338	BTU/lb		18473.9		18473.4
API Gravity	ASTM D 1289	°API		58.6	58.7	58.6
Specific gravity (60°F/60°F)				0.7443	0.7440	0.7443
Fuel economy numerator (g carbon/gal)			2401-2441	2435		2435
Fuel economy numerator (g carbon/gal) with R Factor				2430		2430

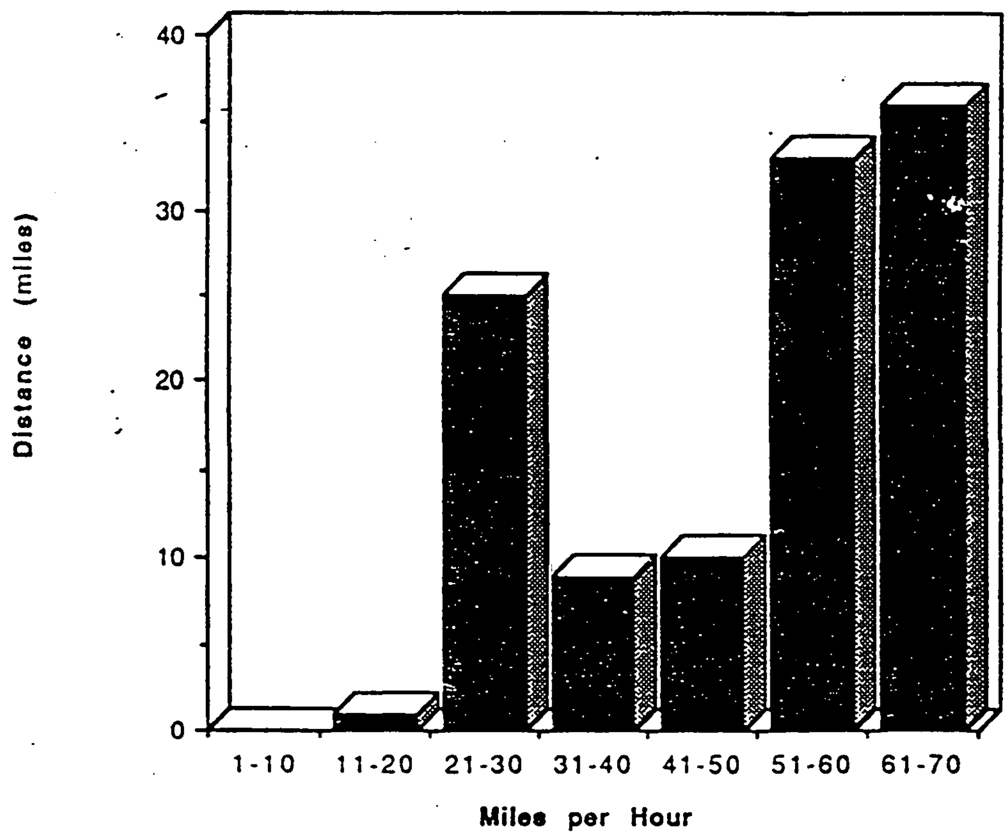
Attachment A

ENGINEERING OPERATIONS DIVISION
Fuel Analysis Report
Milage Accumulation Gasoline

				Before the Addition of MMT			After the Addition of MMT		
			Tested by:	F&CS	Core	Official EOD	F&CS	Core	Official EOD
			Where:	Tank #5	Tank #5	Tank #5	Tank #5	Tank #5	Tank #5
			When:	15-Jun-90	15-Jun-90	19-Jun-90	15-Jun-90	15-Jun-90	19-Jun-90
Item	Method	Units	Target						
RVP Herzog Digital	ASTM D 4953	psi		9.1		9.1	9.1		9.1
Distillation	ASTM D 86								
initial boiling point		°F		86.7		87	86.7		87
5% evaporated		°F		11.7		12	11.7		12
10% evaporated		°F	158 Max	123.9		124	123.9		124
20% evaporated		°F		142.5		143	142.5		143
30% evaporated		°F		162.1		162	162.1		162
40% evaporated		°F		186.0		186	186.0		186
50% evaporated		°F	170-250	214.5		215	214.5		215
60% evaporated		°F		243.3		243	243.3		243
70% evaporated		°F		275.0		275	275.0		275
80% evaporated		°F		312.0		312	312.0		312
90% evaporated		°F	374 Max	355.1		355	355.1		355
95% evaporated		°F		415.5		416	415.5		416
end point		°F	437 Max.	452.0		470	452.0		470
evaporated at 160 °F		Vol %		30.5		30.5	30.5		30.5
Sulfur	ASTM D 1266	wt%	0.10 MAX.		0.0662	0.0662		0.0699	0.0699
Lead	F&CS X-Ray	g/gal	0.05 MAX.	<0.005		<0.005	<0.005		<0.005
Manganese	F&CS X-Ray	g/gal	(a)	<0.005		<0.005	0.031		0.031
Phosphorous	ASTM D 3231	g/gal	0.005 MAX.		<0.0001	<0.0001		<0.0001	<0.0001
Water (Wt%)	Karl Fische	Wt %	(a)						
Hydrocarbon Compositio	ASTM D 1319								
olefins		Vol %	(a)	9.1		9.1	9.1		9.1
aromatics		Vol %	(a)	27.9		27.9	27.9		27.9
saturates		Vol %	(a)	63.0		63.0	63.0		63.0
Research octane number	ASTM D 2699		(a)		90.6	90.6		91.7	91.7
Motor octane number	ASTM D 2700		(a)		82.2	82.2		83.0	83.0
Antiknock index	ASTM D 439		87.0		86.4	86.4		87.4	87.4
Sensitivity	RON-MON		(a)		8.4	8.4		8.7	8.7
Weight fraction carbon	ASTM D 2789		(a)						
Weight fraction carbon	ASTM E 191		(a)						
Weight fraction carbon	ASTM D 3343		(a)	0.8640		0.8640	0.8640		0.8489
Net heat of combustion	ASTM D 240	BTU/lb	(a)						
Net heat of combustion	ASTM D 3338	BTU/lb	(a)	18512.9		18503.5	18512.9		18878.9
API Gravity	ASTM D 1289	°API	(a)	59.6	59.3	59.6	59.6	59.3	59.6
Specific gravity (60°F/60°F)			(a)	0.7405	0.7416	0.7405	0.7405	0.7416	0.7405
Fuel economy numerator (g carbon/gal)			(a)	2417		2417	2417		2375
Fuel economy numerator (g carbon/gal) with R Factor				2417		2418	2417		2347

Attachment C

MMT Mileage Accumulation Route
17 August 1990



A999EOD-8888 9/25/90

MFR	VEHICLE ID	1990 Taurus 3.0L V6 VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
30 FORD	A999EOD-8888	1FACP52U8LG159954	90	6.8	3625	18.0	7.2	56444	D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	Mn Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
904725	8/10/90	21	FTP	3883.5	0.204	3.676	431.0	0.505	20.3	0.0028	N			297	298	75.5	29.14	55.0
904739	8/14/90	21	FTP	3942.2	0.217	3.798	427.3	0.493	20.5	0.0492	Y		Other	311	312	75.5	29.23	52.8
904726	8/21/90	21	FTP	5564.5	0.265	4.436	434.1	0.576	20.1	0.0679	Y		Other	329	330	75.5	29.18	52.9
904727	8/23/90	21	FTP	6170.0	0.241	4.414	426.7	0.580	20.4	0.0642	Y	13.0%	Other	337	338	73.5	29.12	55.5
904729	8/27/90	21	FTP	7456.0	0.250	3.458	423.8	0.555	20.6	0.0832	Y	15.0%	Other	352	353	74.0	29.14	63.9
905021	9/6/90	21	FTP	11092.3	0.298	4.836	424.2	0.541	20.5	0.0553	Y	15.0%	Other	406	407	75.5	29.05	51.1
905191	9/7/90	21	FTP	11165.5	0.264	4.342	418.3	0.616	20.9	0.0079	N	0.0%		422	423	75.5	28.91	47.6
905194	9/10/90	21	FTP	11791.8	0.261	4.033	427.0	0.551	20.5	0.0038	N	3.0%		440	441	75.5	29.13	53.0
904728	9/13/90	21	FTP	11912.4	0.258	4.584	416.0	0.581	21.0	0.0246	Y	13.0%	HiTec	488	489	75.5	29.23	49.9
904738	8/10/90	21	HWY	3894.4	0.022	0.483	257.8	0.139	34.3	0.0049	N			299	300	75.0	29.13	54.4
904748	8/14/90	21	HWY	3953.0	0.022	0.419	261.3	0.225	33.9	0.0497	Y		Other	313	314	75.0	29.22	52.8
904772	8/21/90	21	HWY	5575.4	0.018	0.267	269.2	0.425	32.9	0.0700	Y		Other	331	332	75.2	29.18	52.9
904773	8/23/90	21	HWY	6180.9	0.021	0.254	264.3	0.309	33.6	0.0779	Y	6.1%	Other	339	340	72.5	29.12	56.1
904933	8/27/90	21	HWY	7666.9	0.021	0.329	268.9	0.388	32.9	0.1022	Y	7.3%	Other	354	355	74.5	29.14	66.3
904742	9/6/90	21	HWY	11103.2	0.031	0.420	261.1	0.293	33.9	0.0541	Y	16.0%	Other	408	409	76.0	29.01	54.2
905192	9/7/90	21	HWY	11176.5	0.027	0.365	261.1	0.201	33.9	0.0105	N	4.0%		424	425	76.0	28.93	49.4
905195	9/10/90	21	HWY	11802.7	0.020	0.263	264.6	0.247	33.5	0.0073	N	5.0%		442	443	76.0	29.15	56.7
904932	9/13/90	21	HWY	11923.4	0.028	0.475	259.1	0.211	34.3	0.0275	Y	7.0%	HiTec	490	491	75.5	29.21	49.5
904737	8/10/90	21	NYCC	3914.4	0.641	28.473	845.1	0.697	10.0	0.0054	N			301	302	75.5	29.13	55.0
904719	8/14/90	21	NYCC	3973.1	0.474	23.220	842.1	0.686	10.1	0.0363	Y		Other	315	316	75.5	29.22	52.8
904780	8/21/90	21	NYCC	5595.6	0.438	20.248	858.0	0.519	10.0	0.0431	Y		Other	333	334	75.5	29.18	53.9
904781	8/23/90	21	NYCC	6201.1	0.545	23.949	851.1	0.787	10.0	0.0477	Y	13.1%	Other	341	342	74.5	29.12	56.7
904783	8/27/90	21	NYCC	7487.1	0.236	5.799	824.4	0.813	10.6	0.0548	Y	9.1%	Other	356	357	73.5	29.14	49.1
904743	9/6/90	21	NYCC	11155.7	0.928	21.350	833.3	0.740	10.2	0.0570	Y	30.0%	Other	418	419	75.5	28.96	53.3
905193	9/7/90	21	NYCC	11196.7	0.663	20.620	828.1	0.765	10.3	0.0092	N	7.0%		426	427	75.5	28.93	49.4
905196	9/10/90	21	NYCC	11823.0	0.816	28.056	841.4	0.692	10.0	0.0196	N	11.0%		444	445	75.5	29.15	57.1
904782	9/13/90	21	NYCC	11963.8	0.947	27.521	812.0	0.67	10.4	0.0264	Y	29.0%	HiTec	492	493	75.5	29.21	49.9

All Particulate values are unweighted

A999EOD-0099 9/25/90

MFR	VEHICLE ID	1990 Cavalier 2.2L 4 cyl VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 0.4	DRIVER ID	DYNO	US Vehicle Leased by EPA
40 GM	A999EOD-0099	1G1JC84GXLJ188325	90	5.6	2750	15.5	6.2	56444	D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn % Emiss.	Mn Source	Filter Number Prim.	Sec.	AMBT °F	BAROM In. Hg	DEW POINT
904730	8/10/90	21	FTP	2160.5	0.164	2.116	335.0	0.189	26.2	0.0049	N			291	292	75.5	29.14	54.0
904731	8/14/90	21	FTP	2221.3	0.148	2.084	326.9	0.132	26.8	0.0258	Y		Other	305	306	75.0	29.23	48.0
904732	8/20/90	21	FTP	2908.7	0.139	1.838	324.0	0.159	27.1	0.0479	Y		Other	321	322	74.5	29.23	49.9
904733	8/24/90	21	FTP	3943.6	0.164	2.456	324.7	0.179	26.9	0.0435	Y	10.0%	Other	343	344	74.5	29.19	46.3
904734	8/28/90	21	FTP	5638.5	0.158	1.711	314.6	0.157	27.9	0.0393	Y	16.0%	Other	360	361	74.5	28.90	55.5
905019	9/5/90	21	FTP	8477.7	0.157	1.856	325.3	0.261	27.0	0.0496	Y	19.0%	Other	400	401	75.5	29.18	58.1
905020	9/11/90	21	FTP	9833.5	0.147	1.684	328.8	0.208	26.8	0.0284	Y	15.0%	HiTec	456	457	75.5	29.30	47.9
905312	9/17/90	21	FTP	10742.7	0.155	1.434	327.8	0.141	26.9	0.0082	Y	81.0% *	HiTec	542	543	77.0	29.38	46.0
904736	8/10/90	21	HWY	2171.7	0.127	1.841	208.8	0.058	41.8	0.0069	N			293	294	75.5	29.14	55.0
904746	8/14/90	21	HWY	2232.5	0.101	1.510	205.0	0.038	42.7	0.0300	Y		Other	307	308	75.5	29.23	51.8
904774	8/20/90	21	HWY	2919.9	0.058	0.927	201.8	0.034	43.6	0.0488	Y		Other	323	324	75.0	29.23	50.8
904775	8/24/90	21	HWY	3954.8	0.101	2.008	198.6	0.052	43.8	0.0610	Y	10.0%	Other	345	346	74.0	29.20	47.1
904934	8/28/90	21	HWY	5649.0	0.052	0.755	196.6	0.063	44.8	0.0609	Y	9.0%	Other	362	363	74.5	28.89	56.5
904740	9/5/90	21	HWY	8488.9	0.059	0.796	202.5	0.062	43.6	0.0536	Y	10.0%	Other	402	403	75.5	29.19	52.9
905018	9/11/90	21	HWY	9844.7	0.053	0.577	208.4	0.067	42.6	0.0330	Y	10.0%	HiTec	458	459	76.0	29.31	47.9
905313	9/17/90	21	HWY	10753.9	0.079	0.656	206.4	0.046	42.9	0.0151	Y	18.0% *	HiTec	544	545	77.3	29.38	44.2
904735	8/10/90	21	NYCC	2192.5	0.159	3.448	682.7	0.437	12.9	0.0062	N			295	296	75.5	29.14	54.0
904747	8/14/90	21	NYCC	2253.2	0.090	2.950	655.4	0.400	13.4	0.0374	Y		Other	309	310	75.5	29.23	53.8
904776	8/20/90	21	NYCC	2940.6	0.125	3.334	660.9	0.431	13.3	0.0464	Y		Other	327	328	75.5	29.23	50.8
904777	8/24/90	21	NYCC	3975.5	0.140	3.074	670.5	0.431	13.1	0.0454	Y	6.0%	Other	347	348	73.5	29.20	47.1
904778	8/28/90	21	NYCC	5670.0	0.089	0.874	651.9	0.443	13.6	0.0340	Y	7.0%	Other	364	365	74.5	28.88	55.5
904741	9/5/90	21	NYCC	8509.7	0.179	3.041	619.0	0.497	14.2	0.0436	Y	14.0%	Other	404	405	75.5	29.19	52.9
904779	9/11/90	21	NYCC	9886.2	0.133	2.797	662.2	0.884	13.3	0.0423	Y	44.0%	HiTec	460	461	75.5	29.31	48.8
905314	9/17/90	21	NYCC	10816.2	0.182	8.494	651.3	0.178	13.4	0.0196	Y	66.0% *	HiTec	546	547	77.0	29.38	44.2
90PartOnly	9/13/90	21	LA4's	???						0.0280	Y		HiTec	504	505		29.21	

* After 700 miles @ 1 gr/gal Mn and 300 miles @ 1/32 gr/gal, all Hitec 3000

All Particulate values are unweighted

A999EOD-0011 9/25/90

MFR	VEHICLE ID	1990 Cavalier 2.2L 4 cyl VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Canadian Vehicle leased by EPA
40 GM	A999EOD-0011	1G1CT51G9LY137286	90	6.2	3000	15.6	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn % Emiss.	Mn Source	Filter Prim.	Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
905055	8/29/90	21	FTP	24338.0	0.208	1.753	360.2	0.231	24.4	0.0193	Y	9.7%	other	376	377	76.5	28.93	52.3
905099	9/12/90	21	FTP	25915.5	0.202	2.537	357.5	0.313	24.6	0.0317	Y	149.0%	HiTec	478	479	76.5	28.93	52.3
905557	9/21/90	21	FTP	26491.8	0.208	2.660	365.0	0.313	24.1	0.0387	Y	9.4%	HiTec	552	553	76.5	29.04	50.2
905056	8/29/90	21	HWY	24356.0	0.035	0.320	245.3	0.100	36.1	0.0710	Y	3.3%	other	378	379	76.5	28.93	52.3
905100	9/12/90	21	HWY	25933.2	0.035	0.381	304.2	0.078	29.2	0.0375	Y	21.0%	HiTec	480	481	76.0	29.24	49.3
905558	9/21/90	21	HWY	26509.6	0.037	0.433	268.4	0.079	33.1	0.0867	Y	2.8%	HiTec	554	555	76.5	29.04	53.1
905057	8/29/90	21	NYCC	24389.0	0.199	1.023	670.0	0.640	13.2	0.0084	Y	6.5%	other	380	381	76.5	28.93	52.3
905101	9/12/90	21	NYCC	25982.2	0.234	7.939	699.2	0.484	12.5	0.0407	Y	58.0%	HiTec	482	483	75.5	29.22	50.8
905559	9/21/90	21	NYCC	26542.5	0.309	4.460	693.2	0.907	12.7	0.0224	Y	4.8%	HiTec	556	557	76.0	29.02	51.2
905560	9/21/90	21	LA4's	26546.2	0.034	0.585	382.3	0.143	23.2	0.0420	Y	11.0%	HiTec	558	559	76.5	29.00	51.6

Bag 2 Emissions Only

All Particulate values are unweighted

A999EOD-0021 9/25/90

MFR	VEHICLE ID	1990 GMC 3/4 Ton Van V8 VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Canadian Vehicle leased by EPA
40 GM	A999EOD 0021	2GCEG25Z0K4145937	89	11.1	5000	22	8.8		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR KILOM.	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn % Emis.	Mn Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
905070	8/29/90	21	FTP	53522.0	0.811	8.344	510.1	0.659	16.9	0.0389	Y	37.0%	Other	368	369	74.5	28.94	50.4
905096	8/31/90	21	FTP	54348.1	1.016	9.533	510.7	0.737	16.8	0.0215	Y	50.0%	Other	386	387	75.5	29.19	52.9
905364	9/13/90	21	FTP	54964.7	0.606	9.222	515.3	0.508	16.8	0.0077	N	57.8%		494	495	75.5	29.15	51.0
905409	9/14/90	21	FTP	55098.5	0.680	9.427	509.8	0.497	16.9	0.0059	Y	19.3%	HiTec	514	515	75.5	28.78	50.7
905435	9/17/90	21	FTP	56420.5	0.620	8.614	519.7	0.523	16.6	0.0063	Y	28.3%	HiTec	530	531	76.5	29.33	45.2
905071	8/29/90	21	HWY	53540.0	0.150	4.452	365.2	0.198	23.8	0.1269	Y	5.0%	Other	370	371	75.0	28.93	51.4
905097	8/31/90	21	HWY	54359.5	0.132	4.329	377.6	0.210	23.0	0.0756	Y	4.0%	Other	388	389	75.5	29.19	53.9
905365	9/13/90	21	HWY	54982.7	0.051	1.651	377.0	0.136	23.4	0.0069	N	4.0%		496	497	75.5	29.11	51.0
905410	9/14/90	21	HWY	55116.6	0.058	2.020	379.3	0.142	23.3	0.0077	Y	4.3%	HiTec	516	517	76.2	28.71	51.8
905436	9/17/90	21	HWY	56438.6	0.058	2.322	379.3	0.118	23.3	0.0100	Y	6.0%	HiTec	532	533	76.5	29.33	45.0
905072	8/29/90	21	NYCC	53573.0	2.484	11.067	896.0	1.201	9.6	0.0205	Y	34.0%	Other	372	373	75.5	28.96	51.3
905098	8/31/90	21	NYCC	54392.0	2.540	11.048	925.0	1.354	9.3	0.0193	Y		Other	390	391	75.5	29.21	53.8
905366	9/13/90	21	NYCC	55082.6	1.248	21.028	899.7	0.681	9.5	0.0157	N	26.0%		498	499	75.5	29.11	49.1
905411	9/14/90	21	NYCC	55216.3	1.573	23.323	899.5	0.743	9.5	0.0195	Y	22.0%	HiTec	518	519	75.5	28.71	62.9
905437	9/17/90	21	NYCC	56538.2	1.424	22.788	926.3	0.766	9.2	0.0204	Y	23.0%	HiTec	534	535	76.0	29.37	46.9

All Particulate values are unweighted

A999EOD-0031 9/25/90

MFR	VEHICLE ID	1990 Chev. 1/2 Ton Van V8 VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Canadian Vehicle leased by EPA
40 GM	A999EOD-0031	9999.0	90	13.6	5000	22	8.8		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR KILOM.	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn % Emis.	Mn Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
905427	9/14/90	21	FTP	13383.9	0.526	5.318	493.3	0.688	17.7	0.0063	Y	11.3%	HiTec	508	509	75.5	28.92	54.4
905432	9/17/90	21	FTP	14761.2	0.531	4.077	505.2	0.596	17.3	0.0042	Y	11.0%	HiTec	536	537	76.5	29.39	47.7
905428	9/14/90	21	HWY	13401.8	0.056	0.990	372.3	0.180	23.8	0.0175	Y	4.1%	HiTec	510	511	76.0	28.91	48.5
905433	9/17/90	21	HWY	14779.1	0.059	1.550	384.3	0.139	23.0	0.0126	Y	4.3%	HiTec	538	539	76.5	29.39	47.7
905429	9/14/90	21	NYCC	13500.7	2.108	21.759	840.2	0.551	10.1	0.0255	Y	24.1%	HiTec	512	513	75.5	28.85	50.9
905434	9/17/90	21	NYCC	14878.0	1.794	15.688	882.0	0.388	9.8	0.0143	Y	12.8%	HiTec	540	541	77.0	29.39	45.8

All Particulate values are unweighted

A999EOD-0077 9/25/90

MFR	VEHICLE ID	1990 Cavalier 2.2L 4 cyl VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
40 GM	A999EOD-0077	1G1JC84G2LJ187797	90	3.8	2750	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emis.	Mn Source	Filter Prim.	Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
905135	8/31/90	21	FTP	3200.0	0.086	0.899	331.7	0.217	26.6	0.0039	N	1.0%		392	393	75.5	29.23	55.9
905179	9/6/90	21	FTP	3242.8	0.095	1.371	330.4	0.236	26.7	0.0089	N	0.0%		414	415	75.5	28.92	57.5
905180	9/7/90	21	FTP	3284.8	0.091	1.279	328.3	0.192	26.9	0.0109	Y	7.1%	HiTec	428	429	75.5	28.99	49.3
905181	9/14/90	21	FTP	4251.5	0.109	1.765	330.6	0.193	26.6	0.0107	Y	13.9%	HiTec	520	521	76.0	28.65	46.2
905136	8/31/90	21	HWY	3211.5	0.009	0.052	208.3	0.033	42.7	0.0225	N	0.0%		394	395	75.5	29.23	54.8
905183	9/6/90	21	HWY	3254.0	0.011	0.080	204.9	0.024	43.3	0.0286	N	1.0%		416	417	76.0	28.90	54.4
905184	9/7/90	21	HWY	3296.1	0.015	0.103	206.7	0.021	42.8	0.0203	Y	6.0%	HiTec	430	431	76.0	29.00	52.4
905185	9/14/90	21	HWY	4262.7	0.014	0.123	207.2	0.020	43.0	0.0677	Y	5.1%	HiTec	522	523	76.2	28.65	52.4
905137	8/31/90	21	NYCC	3232.6	0.028	0.127	660.5	0.434	13.4	0.0118	N	1.0%		396	397	75.5	29.23	55.9
905187	9/6/90	21	NYCC	3274.8	0.076	1.885	655.0	0.445	13.5	0.0114	N	0.0%		420	421	76.0	28.90	54.4
905188	9/7/90	21	NYCC	3316.9	0.066	1.548	654.5	0.447	13.5	0.0145	Y	8.3%	HiTec	432	433	75.5	29.01	52.2
905189	9/14/90	21	NYCC	4325.0	0.076	3.711	662.2	0.456	13.3	0.0177	Y	18.2%	HiTec	524	525	76.5	28.65	48.6

All Particulate values are unweighted

MFR	VEHICLE ID	1990 Taurus 3.0L V6 VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
30 Ford	A999EOD-0024	1FACP552UMLG159952	90	6.8	3625	18	7.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	Mn Source	Filter Prim.	Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
905307	9/11/90	21	FTP	11508.0	0.272	3.526	424.6	0.762	20.6	0.0040	N	0.0%		462	463	75.5	29.32	49.7
905327	9/12/90	21	FTP	11548.6	0.269	2.996	419.4	0.806	21.0	0.0306	Y	5.6%	HITec	472	473	75.5	29.23	49.9
905308	9/11/90	21	HWY	11518.9	0.012	0.159	253.9	0.445	35.0	0.0092	N	0.0%		464	465	76.0	29.31	50.7
905328	9/12/90	21	HWY	11559.5	0.012	0.160	251.7	0.490	35.3	0.0300	Y	5.5%	HITec	474	475	76.0	29.24	49.9
905309	9/11/90	21	NYCC	11521.2	0.517	24.799	836.9	0.766	10.1	0.0111	N	0.0%		466	467	75.5	29.31	51.7
905329	9/12/90	21	NYCC	11609.7	0.634	26.693	826.6	0.581	10.2	0.0386	Y	18.7%	HITec	476	477	76.0	29.26	55.8

All Particulate values are unweighted

A999EOD-0041 10/4/90

MFR	VEHICLE ID	1991 Sunbird 2.0L 4 cyl VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
40 GM	A999EOD-0041	1G2JB54K2M7506339	91	5.6	2875	13.6	5.4		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
905620	9/25/90	21	FTP	4170.4	0.130	2.567	338.9	0.175	25.9	0.0027	N	0.0%		564	565	76.5	28.84	48.7
905678	9/28/90	21	FTP	4252.8	0.129	3.500	329.2	0.098	26.6	0.0282	Y	6.6%	HiTec	603	604	75.5	29.18	47.2
910027	10/2/90	21	FTP	4335.0	0.114	3.318	337.8	0.122	25.9	0.0377	Y	8.1%	HiTec	617	618	75.5	29.21	44.5
905622	9/25/90	21	HWY	4181.4	0.100	3.051	212.7	0.028	40.9	0.0032	N	0.2%		566	567	76.7	28.78	51.0
905623	9/28/90	21	HWY	4263.8	0.143	6.346	207.2	0.050	40.9	0.0450	Y	6.9%	HiTec	607	608	75.0	29.18	50.0
910028	10/2/90	21	HWY	4346.0	0.085	3.533	211.9	0.041	40.9	0.0681	Y	4.0%	HiTec	619	620	75.9	29.23	50.3
905621	9/25/90	21	NYCC	4242.9	0.040	3.911	707.6	0.469	12.5	0.0125	N	0.0%		568	569	76.5	28.78	53.6
905624	9/28/90	21	NYCC	4325.1	0.050	2.732	668.1	0.236	13.2	0.0659	Y	20.9%	HiTec	609	610	75.5	29.18	51.9
910029	10/2/90	21	NYCC	4387.1	0.058	3.478	727.2	0.153	12.1	0.0392	Y	8.9%	HiTec	621	622	76.0	29.24	51.8

All Particulate values are unweighted

A999EOD-0051 10/26/90

MFR	VEHICLE ID	1991 Dynasty 3.3L V6 VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
20 Chry	A990EOD-0051	1B3XC46R3M0103206	91	8.5	3375	16	6.4		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. MILES	HC-HFID g/ml	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn% Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
905614	9/25/90	21	FTP	2126.0		0.290	2.137	426.6	0.423	20.6	0.0030	N	0.0%		570	571	76.5	28.78	53.6
905634	9/26/90	21	FTP	2209.0		0.332	2.025	425.5	0.506	20.7	0.1275	Y	10.4%	HiTec	579	580	76.5	28.83	47.8
905677	9/28/90	21	FTP	2250.0		0.288	2.067	428.2	0.415	20.6	0.0950	Y	14.7%	HiTec	611	612	75.5	29.18	51.9
910024	10/2/90	21	FTP	2292.0		0.299	2.157	428.6	0.397	20.5	0.1189	Y	13.4%	HiTec	623	624	75.5	29.24	42.8
910276	10/5/90	21	FTP	2344.0		0.279	1.865	424.1	0.378	20.8	0.0547	Y	To ORD	HiTec	689	690	75.5	29.02	50.2
910364	10/12/90	21	FTP	2416.0	0.318	0.290	1.939	422.2	0.421	20.9	0.0775	Y	9.4%	HiTec	775	776	75.5	29.15	50.0
905617	9/25/90	21	HWY	2137.0		0.087	0.446	289.7	0.094	30.6	0.0015	N	0.08%		572	573	76.4	28.75	54.1
905635	9/26/90	21	HWY	2220.0		0.065	0.508	287.3	0.068	30.9	0.1348	Y	6.3%	HiTec	581	582	76.0	28.86	47.7
905618	9/28/90	21	HWY	2261.0		0.068	0.576	291.7	0.065	30.4	0.1156	Y	8.8%	HiTec	613	614	75.3	29.17	54.1
910025	10/2/90	21	HWY	2303.0		0.059	0.558	286.3	0.074	31.0	0.1164	Y	9.3%	HiTec	625	626	75.3	29.22	40.7
910277	10/5/90	21	HWY	2355.0		0.059	0.546	284.3	0.073	31.2	0.0404	Y	To ORD	HiTec	691	692	75.0	29.03	49.5
910365	10/12/90	21	HWY	2427.0	0.073	0.063	0.607	281.3	0.079	31.5	0.0747	Y	4.3%	HiTec	777	778	76.5	29.15	52.3
910591	10/25/90	21	HWY	2460.0		0.056	0.592	275.0	0.055	32.2	0.1685	Y		HiTec	793	794	75.5	29.15	44.9
910592	10/25/90	21	HWY	2480.0		0.046	0.521	279.7	0.071	31.7	0.1610	Y		HiTec	795	796	75.5	29.16	45.4
910593	10/25/90	21	HWY	2516.0		0.067	0.512	282.9	0.125	31.4	0.1212	Y	0.1% S	HiTec	797	798	75.4	29.18	45.4
910594	10/25/90	21	HWY	2537.0		0.075	0.943	282.4	0.158	31.3	0.1342	Y	0.1% S	HiTec	799	800	75.5	29.18	44.5
905616	9/25/90	21	NYCC	2199.0		0.140	0.695	844.5	0.878	10.5	0.0127	N	0.0%		574	575	76.5	28.72	58.9
905636	9/26/90	21	NYCC	2240.0		0.343	2.052	831.2	1.025	10.7	0.0918	Y	8.2%	HiTec	583	584	76.5	28.87	46.8
905619	9/28/90	21	NYCC	2282.0		0.273	2.196	831.3	0.728	10.7	0.0834	Y	23.1%	HiTec	615	616	75.5	29.16	53.9
910026	10/2/90	21	NYCC	2334.0		0.185	1.558	839.8	0.622	10.6	0.1070	Y	19.2%	HiTec	627	628	75.5	29.21	41.2
910278	10/5/90	21	NYCC	2406.0		0.181	1.939	839.5	0.552	10.6	0.0236	Y	To ORD	HiTec	693	694	75.5	29.03	50.2
910366	10/12/90	21	NYCC	2457.0	0.325	0.298	0.933	821.0	1.024	10.8	0.0826	Y	7.3%	HiTec	779	780	76.0	29.14	54.0

All Particulate values are unweighted

A999EOD-0015 10/4/90

MFR	VEHICLE ID	1988 Buick Century 2.5L 4 cyl VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
40 GM	A999EOD-0015	1G4AH51R8JT450644	88	6.3	3000	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn % Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
910133	10/3/90	21	FTP	75411.3	0.156	2.799	333.6	0.315	26.3	0.0038	N	0.7%		635	636	75.5	29.18	47.2
910134	10/3/90	21	HWY	75422.5	0.036	0.491	227.8	0.156	38.9	0.0067	N	0.0%		637	638	75.8	29.16	50.0
910135	10/3/90	21	NYCC	75484.5	0.263	8.659	642.3	0.536	13.6	0.0235	N	0.0%		639	640	75.5	29.14	48.2

All Particulate values are unweighted

A999EOD-0016 10/18/90

MFR	VEHICLE ID	1988 Buick Century 2.5L 4 cyl VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
40 GM	A999EOD-0016	1G4AH51RXJT450743	88	6.3	3000	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/ml	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Y/N	Mn % Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
910130	10/3/90	21	FTP	75506.5		0.221	3.769	355.4	0.389	24.6	0.0203	Y	19%	HITec	647	648	75.5	28.85	57.7
910338	10/17/90	21	FTP	75576.1	0.215	0.189	3.146	342.0	0.363	25.6	0.0124	N	34%		785	786	75.5	29.01	53.2
910131	10/3/90	21	HWY	75517.6		0.050	0.730	238.3	0.279	37.2	0.0505	Y	5.6%	HITec	649	650	75.3	28.85	58.3
910334	10/17/90	21	HWY	75587.2	0.111	0.046	0.616	236.9	0.243	37.4	0.0180	N	7.1%		787	788	75.0	29.01	52.2
910132	10/3/90	21	NYCC	75558.7		0.408	8.376	670.8	0.696	13.0	0.0206	Y	13%	HITec	651	652	75.5	28.85	58.8
910336	10/17/90	21	NYCC	75648.6	0.270	0.245	9.343	668.3	0.655	13.0	0.0232	N	25%		789	790	75.5	28.87	51.9

All Particulate values are unweighted

A999EOD-0017 10/4/90

MFR	VEHICLE ID	1988 Buick Century 2.8L V6 VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
40 GM	A999EOD-0017	1G4AH51WXJT451509	88	6.3	3125	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
910142	10/3/90	21	FTP	77473.2	0.295	3.635	387.4	0.355	22.6	0.0049	N	0.6%		641	642	75.5	29.07	54.1
910143	10/3/90	21	HWY	77484.3	0.018	0.106	250.8	0.503	35.5	0.0059	N	0.0%		643	644	75.3	29.07	53.9
910144	10/3/90	21	NYCC	77545.2	0.438	5.228	723.7	1.087	12.1	0.0271	N	0.0%		645	646	75.5	29.07	56.2

All Particulate values are unweighted

MFR	VEHICLE ID	1988 Buick Century 2.8L V6 VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
40 GM	A999EOD-0018	1G4AH51W4JT451537	88	6.3	3125	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/mi	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
910212	10/[illegible]/90	21	FTP	75255.7	0.247	0.377	3.852	402.7	0.232	21.7	0.0366	Y	11%	HiTec	669	670	75.5	28.92	46.7
910340	10/10/90	21	FTP	75337.7	0.512	0.507	5.361	401.2	0.249	21.7	0.0812	Y	27%	HiTec	711	712	75.5	28.86	62.1
910341	10/11/90	21	FTP	75379.0	0.363	0.354	3.777	397.2	0.251	22.0	0.0146	N	5.5%		733	734	75.5	29.24	46.2
910213	10/4/90	21	HWY	75266.7	0.080	0.028	0.243	252.1	0.048	35.2	0.0344	Y	6.5%	HiTec	671	672	75.0	28.92	47.2
910342	10/10/90	21	HWY	75348.7	0.037	0.037	0.467	250.3	0.059	35.4	0.0838	Y	5.8%	HiTec	713	714	75.5	28.86	51.3
910343	10/11/90	21	HWY	75390.0	0.011	0.016	0.165	250.7	0.115	35.5	0.0133	N	2.0%		735	736	75.6	29.24	46.2
910214	10/4/90	21	NYCC	75327.8	0.696	0.680	8.426	761.3	1.024	11.5	0.0471	Y	18%	HiTec	673	674	75.5	28.94	47.8
910344	10/10/90	21	NYCC	75369.1	1.021	0.989	10.491	751.2	0.741	11.5	0.0527	Y	8.1%	HiTec	715	716	75.5	28.85	53.5
910345	10/11/90	21	NYCC	75451.2	0.532	0.590	7.533	734.8	0.921	11.9	0.0323	N	4.3%		737	738	75.5	29.24	46.2

All Particulate values are unweighted

A999EOD-0019 10/18/90

MFR	VEHICLE ID	1988 Crown Victoria 5.0L V8	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
30 Ford	A999EOD-0019	2FABP73F2JX216499	89	11.4	4000	18	7.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/mi	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Prim.	Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
910491	10/4/90	21	FTP	72091.0	N/A	0.515	2.054	458.3	1.161	19.3	0.0072	N	0.6%		679	680	75.5	28.96	45.7
910492	10/4/90	21	HWY	72102.0	0.103	0.089	0.109	286.7	0.405	31	0.0019	N	0.35%		675	676	75.0	28.93	46.2
910493	10/4/90	21	NYCC	72162.0	0.920	0.917	2.523	902.0	2.151	9.8	0.0186	N	0.7%		677	678	75.5	28.93	43.2

All Particulate values are unweighted

A999EOD-0020 10/11/90

MFR	VEHICLE ID	VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
30 Ford	A999EOD-0020	2FABP73F9JX216497	89	11.4	4000	18	7.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/ml	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn % Emiss.	MN Source	Filter Prim.	Number Sec.	AMBT °F	BAROM In. Hg	DEW POINT
910206	10/4/90	21	FTP	72530.0	0.855	0.857	2.373	461.3	0.612	19.0	0.0356	Y	11%	HiTec	681	682	75.5	28.92	49.5
910328	10/10/90	21	FTP	72618.0	1.130	1.093	5.018	458.8	0.576	18.9	0.1083	Y	11%	HiTec	706	706	75.5	28.90	51.4
910329	10/11/90	21	FTP	72669.0	0.748	0.709	1.234	459.8	0.625	19.2	0.0105	N	4.2%		727	728	75.5	29.16	43.7
910207	10/4/90	21	HWY	72541.0	0.314	0.301	0.116	291.2	0.247	30.4	0.0200	Y	6.3%	HiTec	683	684	75.0	28.94	48.5
910330	10/10/90	21	HWY	72629.0	0.386	0.372	0.405	290.1	0.251	30.5	0.0910	Y	4.9%	HiTec	707	708	75.7	28.89	53.4
910331	10/11/90	21	HWY	72679.0	0.235	0.224	0.064	287.9	0.309	30.8	0.0124	N	1.2%		729	730	75.3	29.19	44.5
910208	10/4/90	21	NYCC	72601.0	2.053	1.943	3.124	922.4	1.191	9.5	0.0396	Y	16%	HiTec	685	686	75.5	28.94	48.5
910309	10/4/90	21	NYCC	72604.0	2.172	2.010	4.388	915.6	1.249	9.6	0.0264	Y	6.2%	HiTec	687	688	75.5	28.94	48.5
910332	10/10/90	21	NYCC	72659.0	2.964	2.802	10.974	894.4	1.359	9.7	0.0722	Y	6.9%	HiTec	709	710	75.5	28.88	56.6
910333	10/11/90	21	NYCC	72740.0	1.012	0.967	0.244	910.8	1.451	9.7	0.0408	N	3.5%		731	732	75.5	29.23	45.3

All Particulate values are unweighted

-27-

Attachment 2

TESTING MATRIX

Sample	Description
1.	Sample flow rate at 1.7 SCFM, using one pair of filters for each of the three segments (bags) of an FTP test. Filter Positions 1 and 3 were used for the filter changes. For HFET and NYCC tests (no filter changes) this became a duplicate of Sample 3 below.
2.	Sample flow rate at 1.0 SCFM, using one pair of filters for each of the three segments (bags) of an FTP test. Filter Positions 2 and 4 were used for the filter changes. For HFET and NYCC tests (no filter changes) this became a duplicate of Sample 4 below.
3.	Sample flow rate at 1.7 SCFM, using one pair of filters for any given test. This was Filter Position # 6.
4.	Sample flow rate at 1.0 SCFM, using one pair of filters for any given test. This is the same sample conditions as used by EPA. The "through the wall sample probe" which matched EPA probe geometry (including tubing length) was used for this sample. This was Filter Position # 5.
5.	Measurement after a 10 micron cyclone. A single filter (Filter Position # 7) was used for any given test.
6.	Measurement after a 2.5 micron cyclone. A single filter (Filter Position # 8) was used for any given test.
7.	Used for Tapered Element Oscillating Microbalance (TEOM) connection. This was identified as Filter Position # 9.
8.	A 20" x 20" filter was used on the tunnel exit to filter the total tunnel flow. This was identified as Filter Position # 10.

Attachment 3

PROTOCOL FOR DATA COLLECTION AT SwRI

Data collection, Day 0

A. Run an emissions test on the automobile, to insure that the gaseous emissions for that automobile are within specifications before using that car for further testing.

B. Accumulate 100 miles @ 30 MPH average, mixed city and highway driving, using clear fuel.

C. LA-4 prep, let stand overnight.

Data collection, Day 1:

A. FTP test. Use two sample probes at 1.0 CFM, and 2 sample probes at 1.7 CFM. On one probe at each flow rate, collect particulates on a single pair of filters (primary and back-up) during all 3 segments (bags) of the FTP test. On the other probe at each flow rate, collect the particulates by changing filter pairs (primary and back-up) during each of the 3 segments (bags) of the FTP test. On the 5th and 6th sample probes, use 10 micron and 2.5 micron cyclones respectively, each with a back-up filter. Use the TEOM on the 7th sample probe. Use a 20" x 20" total filter on the end of the tunnel.

B. LA-4 prep.

Data collection, Day 2:

A. FTP heat build.

B. FTP test. Use two sample probes at 1.0 CFM, and 2 sample probes at 1.7 CFM. On one probe at each flow rate, collect particulates on a single pair of filters (primary and back-up) during all 3 segments (bags) of the FTP test. On the other probe at each flow rate, collect the particulates by changing filter pairs (primary and back-up) during each of the 3 segments (bags) of the FTP test. On the 5th and 6th sample probes, use 10 micron and 2.5 micron cyclones respectively, each with a back-up filter. Use the TEOM on the 7th sample probe. Use a 20" x 20" total filter on the end of the tunnel.

C. Highway Cycle. Use two sample probes at 1.0 CFM, and 2 sample probes at 1.7 CFM. On all 4 of these probes, collect particulates on a single pair of filters (primary and back-up). On the 5th and 6th sample probes, use 10 micron and 2.5 micron cyclones, each with a back-up filter. Use the TEOM on the 7th sample probe. Use a 20" x 20" total filter on the end of the tunnel.

D. NYCC Cycle. Use two sample probes at 1.0 CFM, and 2 sample probes at 1.7 CFM. On all 4 of these probes, collect particulates on a single pair of filters (primary and back-up). On the 5th and 6th sample probes, use 10 micron and 2.5 micron cyclones, each with a back-up filter. Use the TEOM on the 7th sample probe. Use a 20" x 20" total filter on the end of the tunnel.

E. LA-4 prep.

Data collection, Day 3:

Repeat the Day 2 tests, verbatim. No LA-4 prep will be required at the end of the day.

Accumulate 100 miles @ 30 MPH average, mixed city and highway driving, using clear fuel. Drain the fuel, and fill to the specified level with fuel containing HiTEC 3000, at a concentration of 0.03125 g Mn/gallon. Perform an LA-4 prep, and let stand overnight.

Repeat the Day 1 - Day 3 data collections, using the fuel containing HiTEC 3000.

Drain the fuel containing HiTEC 3000, and fill with clear fuel. Accumulate 100 miles @ 30 MPH average, mixed city and highway driving, using clear fuel. Perform an LA-4 prep, and let stand overnight.

Repeat the Day 1 - Day 3 data collections, using the fuel without manganese.

Accumulate 100 miles @ 30 MPH average, mixed city and highway driving, using clear fuel. Drain the fuel, and fill to the specified level with fuel containing HiTEC 3000, at a concentration of 0.03125 g Mn/gallon. Perform an LA-4 prep, and let stand overnight.

Repeat the Day 1 - Day 3 data collections, using the fuel containing HiTEC 3000.

Attachment 4

Systems Applications
International

4600 Marriott Dr., Suite 420, Raleigh, NC 27612
919-782-1033 Facsimile 919-782-1716
A Division of Clement International Corporation
Environmental and Health Sciences

TECHNICAL MEMORANDUM

TO: Ethyl Corporation

FROM: Ralph L. Roberson, P.E. *Ralph L. Roberson*

DATE: June 19, 1991

SUBJECT: Analysis of Particulate Emission Test Data

INTRODUCTION

In early 1991, Ethyl Corporation contracted with Southwest Research Institute (SwRI) to conduct a comprehensive particulate emission testing program. The testing program examined a number of variables (i.e., sampling rate, filter configuration, and particle size) that could influence particulate measurements. The sampling program is described in detail in Appendix 5.

Ethyl Corporation asked Systems Applications International (SAI) to analyze the particulate test data from this program, with special emphasis on the data obtained in accordance with the particulate sampling procedure established by EPA for determining particulate emissions from diesel-fueled engines. These data are labeled "Sampling Point 5" in Appendix 5. A listing of the particulate emission data analyzed by SAI is attached to this memorandum. Ethyl also asked SAI to analyze the data it obtained on the percentage of input manganese emitted.

DISCUSSION OF TEST FLEET

The test fleet included five car models and seven individual cars. The first three car models were three relatively low mileage cars (i.e., 3.1L Chevrolet Lumina, 3.0L Chrysler Lebaron, and 5.0L Ford Crown Victoria), which were leased by SwRI for the testing program. The second two car models tested were two pairs of cars from the original Ethyl test fleet. The Ethyl fleet cars were a pair of 2.0L Chevrolet Cavaliers and a pair of 3.8L Buick Centurys. Each Ethyl fleet car had previously accumulated approximately 75,000 miles, one car from each pair burning clear fuel and the other burning fuel containing the HiTEC 3000 fuel additive. As explained in Appendix 5, the SwRI-leased cars were tested sequentially with clear fuel and fuel containing the HiTEC 3000 fuel additive. For the Ethyl fleet cars, the original clear-fuel cars were tested only with the clear fuel. The original HiTEC 3000 cars were tested only with fuel containing the HiTEC 3000 fuel additive.

RESULTS OF DATA ANALYSIS -- SAMPLE POINT 5

For our initial analysis, we simply average all clear-fuel measurements and all HiTEC 3000 measurements obtained from Sampling Point 5. In this analysis we are averaging particulate emissions across five car models and three distinct driving cycles: (1) the Federal Test Procedure (FTP), (2) the Highway Fuel Economy Test (HFET), and (3) the New York City Cycle (NYCC). The results are shown below.

Fuel	Number of Tests	Average Particulate Emissions (gm/mile)
Clear	68	0.0077
HiTEC	70	0.0103

Next, we compute average particulate emissions for each of the three driving cycles for Sampling Point 5. These results are shown in Table 1. Table 1 shows that the highest average particulate emissions for both clear fuel and fuel containing the HiTEC 3000 additive are obtained for the HFET. In absolute terms, the average difference in particulate emissions between clear fuel and fuel with HiTEC 3000 is relatively small for all three driving cycles and ranges from 0.0019 gram/mile for the FTP to 0.0035 gram/mile for the NYCC.

RESULTS OF DATA ANALYSIS -- ALL SAMPLE POINTS

The comprehensive particulate emission testing program carried out by SwRI produced numerous data points which, in turn, creates the opportunity for a variety of statistical analyses. SAI believes that a reasonable first step is to simply examine arithmetic average particulate emissions for all particulate sampling points (i.e., sampling configurations). We sort the data in the same manner as for our analysis of the data obtained for Sampling Point 5. That is, we average across all clear-fuel measurements and across all HiTEC 3000 measurements. Next, we average across each of the three driving cycles for all sampling points. Results of these calculations are shown in Table 2.

Inspection of Table 2 shows that there are some differences in average particulate emissions among different sampling points. However, the differences are relatively small and tend to confirm the results obtained for Sampling Point 5. Accordingly, SAI did not conduct any additional statistical analysis of the particulate emission data.

ANALYSIS OF MANGANESE DATA

Particulate samples obtained by SwRI for the first testing sequence for Sampling Points 5 and 8 were sent to the Ethyl Corporation for analysis of manganese concentration. From the first test sequence, Ethyl analyzed all of the Sampling Point 5 filters (35) and the first run FTP, HFET, and NYCC filters for Sampling Point 8 (15). Analytical results were provided to SAI by Ethyl in the units of percentage of input manganese emitted.

As explained in Appendix 5, the first testing sequence consisted of three FTPs, two HFETS, and two NYCCs. Sampling Point 8 is the one that utilized a 2.5 micrometer (μ) cyclone collector in front of the particulate filter.

Using the analytical results provided by Ethyl, SAI computed the following average manganese emission rates.

Driving Cycle	Percent of Input Manganese Emitted (%) Sampling Point 5	2.5 μ Cyclade
All Data	10.2	10.2
FTP	11.2	9.8
HFET	7.2	7.4
NYCC	11.7	13.4

ANALYSIS OF ADDITIONAL SWRI DATA

Following completion of the previously discussed testing program, SwRI conducted additional particulate testing on two of the Ethyl fleet cars. SwRI tested the two cars, which had previously accumulated over 75,000 miles on fuel with the HiTEC 3000 additive, on clear fuel. For the 2.0L Chevrolet Cavalier, SwRI replicated a test sequence that consisted of 3 FTPs, 2 HFETs, and 2 NYCCs. This is the same sequence as that used to conduct the initial particulate emission tests. For the 3.8L Buick Century, SwRI was not able to replicate the test sequence because the car was needed for the EPA/Ethyl correlation study. SAI recomputed average clear-fuel particulate emissions using the above-described data set. In these calculations, the clear-fuel fleet averages and the HiTEC 3000 fleet averages are based on the same five vehicles. Average particulate emissions in grams per mile, based on Sampling Point 5, are summarized below.

Driving Cycle	Clear Fuel	HiTEC	Emission Difference (HiTEC-Clear)
All Data	0.0089	0.0103	0.0014
FTP	0.0056	0.0071	0.0015
HFET	0.0132	0.0150	0.0018
NYCC	0.0098	0.0106	0.0008

SUMMARY

Analysis of the particulate emission data obtained by SwRI indicates that use of the HiTEC 3000 fuel additive in the test vehicles resulted in a slight increase in particulate emissions. The amount of the increase varied among car models and driving cycles, but was reasonably consistent for all sampling points.

Based on all of the initial data collected for Sampling Point 5, the increase in average particulate emissions is about 0.0026 gram/mile. Based on all of the initial data collected for Sampling Point 5 for the FTP driving cycle, the increase in average particulate emissions is about 0.0019 gram/mile. Using the subsequent SwRI data, which eliminates potential car effects between the Ethyl fleet cars, the increase in average particulate emissions appears to be even smaller than that reported for the initial SwRI data. Based on analysis of particulate samples collected by SwRI, the percent of input manganese emitted ranges from 7.2 percent for the HFET to 11.7 percent for the NYCC. The average across all tests is 10.2 percent.

RLR/chw

Attachment

TABLE 1. AVERAGE PARTICULATE EMISSIONS FOR SWRI TESTS FOR SAMPLING POINT 5. [gm/mile]

Driving Cycle	Clear Fuel	HiTEC	Emission Difference (HiTEC-Clear)
FTP	0.0052	0.0071	0.0019
HFET	0.0119	0.0150	0.0031
NYCC	0.0071	0.0106	0.0035

TABLE 2. AVERAGE PARTICULATE EMISSIONS FOR SwRI TESTS FOR ALL SAMPLING POINTS. [gm/mile]

	Sample Point 1/2		Sample Point 3/4		Sample Point 5		Sample Point 6		2.5 µ Cyclade		10 µ Cyclade		20 x 20 Filter	
	Clear	HiTEC	Clear	HiTEC	Clear	HiTEC	Clear	HiTEC	Clear	HiTEC	Clear	HiTEC	Clear	HiTEC
All Data	0.0078	0.0103	0.0082	0.0106	0.0077	0.0103	0.0070	0.0092	0.0075	0.0102	0.0069	0.0097	0.0059	0.0073
FTP	0.0051	0.0069	0.0053	0.0076	0.0052	0.0071	0.0047	0.0061	0.0039	0.0062	0.0039	0.0068	0.0043	0.0055
HFET	0.0114	0.0144	0.0105	0.0135	0.0119	0.0150	0.0117	0.0148	0.0077	0.0101	0.0068	0.0091	0.0090	0.0117
NYCC	0.0079	0.0111	0.0100	0.0122	0.0071	0.0106	0.0057	0.0084	0.0124	0.0165	0.0118	0.0151	0.0051	0.0055

TABLE 3

VEHICLE	TEST & DAY	SAMPLE POINT	TOTAL PARTICULATE, MG/MILE — WITHOUT Mn RUN 1	RUN 2	AVG.	WITH Mn RUN 1	RUN 2	AVG.
FORD CROWN VICTORIA	FTP; DAY 1	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	7.803	9.866	8.835	12.095	6.239	9.167
FORD CROWN VICTORIA	FTP; DAY 1	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	6.544	11.194	8.869	11.844	7.651	9.748
FORD CROWN VICTORIA	FTP; DAY 1	POINT 5 (1.0 SCFM; 1 FILTER)	6.749	10.179	8.464	12.442	6.700	9.571
FORD CROWN VICTORIA	FTP; DAY 1	POINT 6 (1.7 SCFM; 1 FILTER)	5.372	7.911	6.642	10.432	5.872	8.152
FORD CROWN VICTORIA	FTP; DAY 1	POINT 7 (AFTER 10 MIC. CYCLADE)	5.504	11.252	8.378	10.666	11.310	10.988
FORD CROWN VICTORIA	FTP; DAY 1	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.879	13.154	9.017	12.293	11.800	12.047
FORD CROWN VICTORIA	FTP; DAY 1	POINT 10 (20" X 20" FILTER)	5.568	9.499	7.534	10.438	4.755	7.597
FORD CROWN VICTORIA								
FORD CROWN VICTORIA	FTP; DAY 2	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)		6.581	6.581	7.525	7.664	7.595
FORD CROWN VICTORIA	FTP; DAY 2	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	5.301	6.986	6.144	6.329	9.143	7.736
FORD CROWN VICTORIA	FTP; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER)	4.193	5.732	4.963	7.058	7.095	7.077
FORD CROWN VICTORIA	FTP; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER)	4.686	5.596	5.141	5.508	6.901	6.205
FORD CROWN VICTORIA	FTP; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	3.268	6.967	5.118	8.050	9.892	8.971
FORD CROWN VICTORIA	FTP; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)		5.490	5.490	9.463	11.656	10.560
FORD CROWN VICTORIA	FTP; DAY 2	POINT 10 (20" X 20" FILTER)	3.448	3.985	3.717	4.379	4.533	4.456
FORD CROWN VICTORIA								
FORD CROWN VICTORIA	HFET; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	23.143	27.101	25.122	49.346	22.300	35.823
FORD CROWN VICTORIA	HFET; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	21.915	25.912	23.914	49.343	21.481	35.412
FORD CROWN VICTORIA	HFET; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	23.676	27.262	25.469	50.077	22.868	36.473
FORD CROWN VICTORIA	HFET; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	22.005	25.879	23.942	53.746	21.964	37.855
FORD CROWN VICTORIA	HFET; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	14.716	20.361	17.539	37.150	17.397	27.274
FORD CROWN VICTORIA	HFET; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	19.412	23.785	21.599	41.422	18.271	29.847
FORD CROWN VICTORIA	HFET; DAY 2	POINT 10 (20" X 20" FILTER)	20.890	24.325	22.608	42.958	18.658	30.808
FORD CROWN VICTORIA								
FORD CROWN VICTORIA	NYCC; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)		6.942	6.942	8.968	10.750	9.859
FORD CROWN VICTORIA	NYCC; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	9.696	7.969	8.833	9.922	7.241	8.582
FORD CROWN VICTORIA	NYCC; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	11.984	7.031	9.508	10.141	15.617	12.879
FORD CROWN VICTORIA	NYCC; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	5.527	6.176	5.852	2.560	14.116	8.338
FORD CROWN VICTORIA	NYCC; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	7.241	8.102	7.672	7.587	13.421	10.504
FORD CROWN VICTORIA	NYCC; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.981	10.133	7.557	9.146	11.261	10.204
FORD CROWN VICTORIA	NYCC; DAY 2	POINT 10 (20" X 20" FILTER)	6.679	2.945	4.812	5.295	8.126	6.711
FORD CROWN VICTORIA								
FORD CROWN VICTORIA	FTP; DAY 3	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	5.900	5.663	5.782	8.562	7.230	7.896
FORD CROWN VICTORIA	FTP; DAY 3	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	5.950	6.729	6.340	9.383	12.676	11.030
FORD CROWN VICTORIA	FTP; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER)	4.046	6.000	5.023	8.367	7.388	7.878
FORD CROWN VICTORIA	FTP; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER)	4.526	5.570	5.048	2.514	7.010	4.762
FORD CROWN VICTORIA	FTP; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	5.126	11.135	8.131	11.966	11.691	11.829
FORD CROWN VICTORIA	FTP; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	6.610	12.367	9.489	13.669	12.223	12.946
FORD CROWN VICTORIA	FTP; DAY 3	POINT 10 (20" X 20" FILTER)	3.256	3.512	3.384	5.546	4.511	5.029
FORD CROWN VICTORIA								
FORD CROWN VICTORIA	HFET; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	22.830	28.131	25.481	47.854	34.915	41.385
FORD CROWN VICTORIA	HFET; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	22.793	27.396	25.095	46.454	34.310	40.382
FORD CROWN VICTORIA	HFET; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	24.128	29.170	26.649	48.464	35.462	41.963
FORD CROWN VICTORIA	HFET; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	22.606	27.847	25.227	47.174	32.050	39.612
FORD CROWN VICTORIA	HFET; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	17.857	21.285	19.571	35.637	25.738	30.688
FORD CROWN VICTORIA	HFET; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	19.751	22.200	20.976	39.501	28.290	33.896
FORD CROWN VICTORIA	HFET; DAY 3	POINT 10 (20" X 20" FILTER)	20.923	25.627	23.275	44.400	28.999	36.700
FORD CROWN VICTORIA								
FORD CROWN VICTORIA	NYCC; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	8.455	6.683	7.569	8.324	12.181	10.253
FORD CROWN VICTORIA	NYCC; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	13.321	5.844	9.583	8.833	17.483	13.158
FORD CROWN VICTORIA	NYCC; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	12.485	6.004	9.245	7.357	13.700	10.529
FORD CROWN VICTORIA	NYCC; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	8.613	4.272	6.443	5.079	11.725	8.402
FORD CROWN VICTORIA	NYCC; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	8.843	9.734	9.289	7.711	13.966	10.839
FORD CROWN VICTORIA	NYCC; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	9.354	7.815	8.585	10.794	14.500	12.647
FORD CROWN VICTORIA	NYCC; DAY 3	POINT 10 (20" X 20" FILTER)	7.155	3.930	5.543	5.708	6.162	5.935

VEHICLE	TEST & DAY	SAMPLE POINT	TOTAL PARTICULATE, MG/MILE — WITHOUT Mn RUN 1	WITHOUT Mn RUN 2	WITHOUT Mn AVG.	WITH Mn RUN 1	WITH Mn RUN 2	WITH Mn AVG.
CHEVROLET LUMINA	FTP; DAY 1	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	5.368	5.393	5.381	6.510	20.409	13.460
CHEVROLET LUMINA	FTP; DAY 1	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	4.283	6.215	5.249	8.066	22.182	15.124
CHEVROLET LUMINA	FTP; DAY 1	POINT 5 (1.0 SCFM; 1 FILTER)	4.834	6.295	5.565	6.439	21.141	13.790
CHEVROLET LUMINA	FTP; DAY 1	POINT 6 (1.7 SCFM; 1 FILTER)	4.867	4.162	4.515	6.042	18.431	12.237
CHEVROLET LUMINA	FTP; DAY 1	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.240	3.383	2.812	4.476	18.297	11.387
CHEVROLET LUMINA	FTP; DAY 1	POINT 7 (AFTER 10 MIC. CYCLADE)	0.804	2.627	1.716	4.220	19.879	12.050
CHEVROLET LUMINA	FTP; DAY 1	POINT 10 (20" X 20" FILTER)	4.110	5.887	4.999	5.094	19.928	12.511
CHEVROLET LUMINA								
CHEVROLET LUMINA	FTP; DAY 2	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	5.796	4.077	4.937	10.762	4.023	7.393
CHEVROLET LUMINA	FTP; DAY 2	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)		3.504	3.504	8.076	3.325	5.701
CHEVROLET LUMINA	FTP; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER)	6.162	3.590	4.876	8.255	3.262	5.759
CHEVROLET LUMINA	FTP; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER)	5.169	4.395	4.782	9.884	3.078	6.481
CHEVROLET LUMINA	FTP; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	3.607	1.808	2.708	5.751	1.989	3.870
CHEVROLET LUMINA	FTP; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	3.490		3.490	5.997	2.479	4.238
CHEVROLET LUMINA	FTP; DAY 2	POINT 10 (20" X 20" FILTER)	4.787	2.797	3.792	4.771	3.238	4.005
CHEVROLET LUMINA								
CHEVROLET LUMINA	HFET; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	9.010	8.971	8.991	13.237	10.045	11.641
CHEVROLET LUMINA	HFET; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	8.761	8.362	8.562	13.141	10.051	11.596
CHEVROLET LUMINA	HFET; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	7.144	7.493	7.319	12.124	9.199	10.662
CHEVROLET LUMINA	HFET; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	8.523	8.770	8.647	13.213	8.990	11.102
CHEVROLET LUMINA	HFET; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	4.204	5.608	4.906	9.089	6.442	7.766
CHEVROLET LUMINA	HFET; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.249	5.182	4.716	10.883	7.547	9.215
CHEVROLET LUMINA	HFET; DAY 2	POINT 10 (20" X 20" FILTER)	4.256	4.131	4.194	5.625	4.687	5.156
CHEVROLET LUMINA								
CHEVROLET LUMINA	NYCC; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	8.828	2.138	5.483	9.228	10.651	9.940
CHEVROLET LUMINA	NYCC; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	8.951	4.608	6.780	12.382	7.284	9.833
CHEVROLET LUMINA	NYCC; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	5.791	5.811	5.801	10.270	12.615	11.443
CHEVROLET LUMINA	NYCC; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)		4.795	4.795	11.094	10.746	10.920
CHEVROLET LUMINA	NYCC; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	3.274	9.372	6.323	14.736	17.871	16.304
CHEVROLET LUMINA	NYCC; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	3.169	24.959	14.064	16.438	21.684	19.061
CHEVROLET LUMINA	NYCC; DAY 2	POINT 10 (20" X 20" FILTER)	4.462	3.038	3.750	6.744	6.934	6.839
CHEVROLET LUMINA								
CHEVROLET LUMINA	FTP; DAY 3	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)		2.912	2.912	7.857	4.724	6.291
CHEVROLET LUMINA	FTP; DAY 3	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	4.751	3.677	4.214	7.656	5.695	6.676
CHEVROLET LUMINA	FTP; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER)	3.661	2.938	3.300	7.574	3.915	5.745
CHEVROLET LUMINA	FTP; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER)	2.883	2.283	2.583	6.344	3.124	4.734
CHEVROLET LUMINA	FTP; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	1.280	1.342	1.311	4.541	3.046	3.794
CHEVROLET LUMINA	FTP; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	1.643	0.958	1.301	5.057	2.676	3.867
CHEVROLET LUMINA	FTP; DAY 3	POINT 10 (20" X 20" FILTER)	2.751	2.655	2.703	6.301	2.905	4.603
CHEVROLET LUMINA								
CHEVROLET LUMINA	HFET; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	11.561	9.969	10.765	13.361	10.686	12.024
CHEVROLET LUMINA	HFET; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	10.812	9.508	10.160	12.241	10.200	11.221
CHEVROLET LUMINA	HFET; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	10.085	8.591	9.338	12.025	9.639	10.832
CHEVROLET LUMINA	HFET; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	10.365	8.461	9.413	13.265	9.938	11.602
CHEVROLET LUMINA	HFET; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	5.188	5.882	5.535	8.909	5.945	7.427
CHEVROLET LUMINA	HFET; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	6.041	7.404	6.723	9.571	7.791	8.681
CHEVROLET LUMINA	HFET; DAY 3	POINT 10 (20" X 20" FILTER)	5.004	4.494	4.749	6.896	4.048	5.472
CHEVROLET LUMINA								
CHEVROLET LUMINA	NYCC; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	8.761	4.303	6.532	8.752	10.251	9.502
CHEVROLET LUMINA	NYCC; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	11.254	4.165	7.710	4.991	11.581	8.286
CHEVROLET LUMINA	NYCC; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	8.400	3.904	6.152	7.776	8.228	8.002
CHEVROLET LUMINA	NYCC; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)		2.496	2.496	10.155	8.568	9.362
CHEVROLET LUMINA	NYCC; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	10.970	12.024	11.497	11.322	21.003	16.162
CHEVROLET LUMINA	NYCC; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	9.583	15.393	12.488	9.409	22.410	15.910
CHEVROLET LUMINA	NYCC; DAY 3	POINT 10 (20" X 20" FILTER)	6.031	5.038	5.535	5.976	5.780	5.878

VEHICLE	TEST & DAY	SAMPLE POINT	TOTAL PARTICULATE, MG/MILE — WITHOUT Mn RUN 1	RUN 2	AVG.	WITH Mn RUN 1	RUN 2	AVG.
CHRYSLER LEBARON	FTP; DAY 1	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	7.611	7.027	7.319	9.165	9.468	9.317
CHRYSLER LEBARON	FTP; DAY 1	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	7.622	7.209	7.416	8.562	8.184	8.373
CHRYSLER LEBARON	FTP; DAY 1	POINT 5 (1.0 SCFM; 1 FILTER)	9.553	7.985	8.769	9.479	8.898	9.189
CHRYSLER LEBARON	FTP; DAY 1	POINT 6 (1.7 SCFM; 1 FILTER)	9.149	8.014	8.582	9.248	8.583	8.916
CHRYSLER LEBARON	FTP; DAY 1	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.768	5.042	4.905	5.523	5.625	5.574
CHRYSLER LEBARON	FTP; DAY 1	POINT 7 (AFTER 10 MIC. CYCLADE)	4.335	3.649	3.992	5.990	7.472	6.731
CHRYSLER LEBARON	FTP; DAY 1	POINT 10 (20" X 20" FILTER)	7.838	6.633	7.236	7.291	5.181	6.236
CHRYSLER LEBARON								
CHRYSLER LEBARON	FTP; DAY 2	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	7.159	6.517	6.838	5.183	7.917	6.550
CHRYSLER LEBARON	FTP; DAY 2	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	7.115	5.448	6.282	12.116	7.847	9.982
CHRYSLER LEBARON	FTP; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER)	8.632	6.586	7.609	5.948	7.407	6.678
CHRYSLER LEBARON	FTP; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER)	8.433	6.600	7.517	5.320	6.961	6.141
CHRYSLER LEBARON	FTP; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	4.794	4.915	4.855	4.661	5.467	5.064
CHRYSLER LEBARON	FTP; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.301	4.954	4.628	3.555	4.780	4.168
CHRYSLER LEBARON	FTP; DAY 2	POINT 10 (20" X 20" FILTER)	6.925	4.973	5.949	5.894	5.971	5.933
CHRYSLER LEBARON								
CHRYSLER LEBARON	HFET; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	14.135	15.700	14.918	14.069	11.998	13.034
CHRYSLER LEBARON	HFET; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	12.614	12.851	12.733	11.865	8.759	10.312
CHRYSLER LEBARON	HFET; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	15.254	17.945	16.600	15.352	13.997	14.675
CHRYSLER LEBARON	HFET; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	16.576	17.969	17.273	17.072	13.932	15.502
CHRYSLER LEBARON	HFET; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	5.338	7.125	6.232	4.708	5.495	5.102
CHRYSLER LEBARON	HFET; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	5.630	6.354	5.992	5.723	5.875	5.799
CHRYSLER LEBARON	HFET; DAY 2	POINT 10 (20" X 20" FILTER)	9.441	6.259	7.850	11.201	10.561	10.881
CHRYSLER LEBARON								
CHRYSLER LEBARON	NYCC; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	7.331	17.587	12.459	6.675	27.901	17.288
CHRYSLER LEBARON	NYCC; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	9.412	29.454	19.433	21.786	28.348	25.067
CHRYSLER LEBARON	NYCC; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)		12.010	12.010	13.604	27.740	20.672
CHRYSLER LEBARON	NYCC; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	8.313	7.173	7.743	7.103	11.063	9.083
CHRYSLER LEBARON	NYCC; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	8.953	49.967	29.460	27.725	34.872	31.299
CHRYSLER LEBARON	NYCC; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	8.428	45.811	27.120	26.273	41.141	33.707
CHRYSLER LEBARON	NYCC; DAY 2	POINT 10 (20" X 20" FILTER)	5.036	4.116	4.576	6.891	7.222	7.057
CHRYSLER LEBARON								
CHRYSLER LEBARON	FTP; DAY 3	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)		4.143	4.143	6.346	7.587	6.967
CHRYSLER LEBARON	FTP; DAY 3	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	7.061	3.891	5.476	7.330	7.662	7.496
CHRYSLER LEBARON	FTP; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER)	6.389	3.840	5.115	6.952	6.803	6.878
CHRYSLER LEBARON	FTP; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER)	5.943	3.350	4.647	6.569	5.839	6.204
CHRYSLER LEBARON	FTP; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	4.587	3.558	4.073	4.639	24.387	14.513
CHRYSLER LEBARON	FTP; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.930	2.925	3.928	4.684	5.739	5.212
CHRYSLER LEBARON	FTP; DAY 3	POINT 10 (20" X 20" FILTER)	5.228	3.402	4.315	5.380	4.714	5.047
CHRYSLER LEBARON								
CHRYSLER LEBARON	HFET; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	12.111	8.815	10.463	11.908	12.272	12.090
CHRYSLER LEBARON	HFET; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	11.299	7.436	9.368	9.021	11.481	10.251
CHRYSLER LEBARON	HFET; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	13.630	9.360	11.495	13.097	14.172	13.635
CHRYSLER LEBARON	HFET; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	14.351	9.890	12.121	14.229	13.342	13.786
CHRYSLER LEBARON	HFET; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	4.973	3.527	4.250	5.181	5.978	5.580
CHRYSLER LEBARON	HFET; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	5.469	3.352	4.411	5.818	6.804	6.311
CHRYSLER LEBARON	HFET; DAY 3	POINT 10 (20" X 20" FILTER)	7.842	5.597	6.720	8.678	8.049	8.364
CHRYSLER LEBARON								
CHRYSLER LEBARON	NYCC; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	13.533	5.897	9.715	18.445	15.307	16.876
CHRYSLER LEBARON	NYCC; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	16.919	12.294	14.607	22.594	8.702	15.648
CHRYSLER LEBARON	NYCC; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)		4.664	4.664	15.889	10.518	13.204
CHRYSLER LEBARON	NYCC; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	9.347	3.875	6.611	11.579	8.356	9.968
CHRYSLER LEBARON	NYCC; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	20.504	27.451	23.978	16.354	45.858	31.106
CHRYSLER LEBARON	NYCC; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	19.814	28.193	24.004	17.239	46.496	31.868
CHRYSLER LEBARON	NYCC; DAY 3	POINT 10 (20" X 20" FILTER)	6.172	5.837	6.005	5.523	3.907	4.715

VEHICLE	TEST & DAY	SAMPLE POINT	WITHOUT Mn RUN 1	WITHOUT Mn RUN 2	WITHOUT Mn AVG.	WITH Mn RUN 1	WITH Mn RUN 2	WITH Mn AVG.
			TOTAL PARTICULATE, MG/MILE					
2.0 l chev	FTP; DAY 1	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	4.294	1.554	2.924	4.230	3.875	4.053
2.0 l chev	FTP; DAY 1	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	4.932	2.886	3.909	4.108	4.801	4.455
2.0 l chev	FTP; DAY 1	POINT 5 (1.0 SCFM; 1 FILTER)	4.430	3.594	4.012	4.671	6.106	5.389
2.0 l chev	FTP; DAY 1	POINT 6 (1.7 SCFM; 1 FILTER)	2.461	2.350	2.406	3.442	5.194	4.318
2.0 l chev	FTP; DAY 1	POINT 7 (AFTER 10 MIC. CYCLADE)	2.970	1.584	2.277	3.480	3.887	3.684
2.0 l chev	FTP; DAY 1	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.043	0.714	1.379	2.786	2.854	2.820
2.0 l chev	FTP; DAY 1	POINT 10 (20" X 20" FILTER)	2.694	3.008	2.851	3.880	5.784	4.832
2.0 l chev								
2.0 l chev	FTP; DAY 2	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	3.319	2.212	2.766	5.240	2.840	4.040
2.0 l chev	FTP; DAY 2	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	2.749	1.710	2.230	5.170	2.743	3.957
2.0 l chev	FTP; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER)	2.915	3.350	3.133	4.979	3.878	4.429
2.0 l chev	FTP; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER)	2.159	2.664	2.412	3.438	2.165	2.802
2.0 l chev	FTP; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	2.396	1.523	1.960	2.417	1.848	2.133
2.0 l chev	FTP; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	1.435	1.528	1.482	2.611	2.058	2.335
2.0 l chev	FTP; DAY 2	POINT 10 (20" X 20" FILTER)	3.325	3.224	3.275	4.331	3.148	3.740
2.0 l chev								
2.0 l chev	HFET; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	1.866	6.492	4.179	2.454	7.264	4.859
2.0 l chev	HFET; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	2.115	5.059	3.587	2.088	5.686	3.887
2.0 l chev	HFET; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	2.745	8.725	5.735	3.874	9.341	6.608
2.0 l chev	HFET; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	1.999	8.204	5.102	2.841	8.366	5.604
2.0 l chev	HFET; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	0.000	1.633	0.817	1.502	1.247	1.375
2.0 l chev	HFET; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	0.000	1.333	0.667	1.873	1.377	1.625
2.0 l chev	HFET; DAY 2	POINT 10 (20" X 20" FILTER)	2.642	9.880	6.261	4.504	10.922	7.713
2.0 l chev								
2.0 l chev	NYCC; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	3.494	13.596	8.545	7.460	17.036	12.248
2.0 l chev	NYCC; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	3.536	13.508	8.522	8.951	19.289	14.120
2.0 l chev	NYCC; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	8.480	8.202	8.341	7.898	9.101	8.500
2.0 l chev	NYCC; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	2.608	6.749	4.679	5.415	10.824	8.120
2.0 l chev	NYCC; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	4.649	1.769	3.209	4.582	6.945	5.764
2.0 l chev	NYCC; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.067	11.313	6.690	6.712	17.987	12.350
2.0 l chev	NYCC; DAY 2	POINT 10 (20" X 20" FILTER)	4.442	4.344	4.393	3.828	4.000	3.914
2.0 l chev								
2.0 l chev	FTP; DAY 3	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	3.021	2.407	2.714	4.175	2.883	3.529
2.0 l chev	FTP; DAY 3	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	3.558	2.656	3.107	4.157	3.133	3.645
2.0 l chev	FTP; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER)	4.028	3.996	4.012	5.365	3.713	4.539
2.0 l chev	FTP; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER)	2.926	1.874	2.400	3.553	2.957	3.255
2.0 l chev	FTP; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	2.397	6.037	4.217	3.323	2.813	3.068
2.0 l chev	FTP; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.139	2.151	2.145	3.769	2.586	3.178
2.0 l chev	FTP; DAY 3	POINT 10 (20" X 20" FILTER)	3.422	2.517	2.970	3.687	2.943	3.315
2.0 l chev								
2.0 l chev	HFET; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	3.599	7.352	5.476	4.249	4.981	4.615
2.0 l chev	HFET; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	3.417	5.919	4.668	3.634	4.111	3.873
2.0 l chev	HFET; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	5.530	9.366	7.448	5.827	7.085	6.456
2.0 l chev	HFET; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	4.142	8.447	6.295	4.988	6.265	5.627
2.0 l chev	HFET; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	2.242	3.164	2.703	1.149	1.037	1.093
2.0 l chev	HFET; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	1.790	3.066	2.428	1.407	0.692	1.050
2.0 l chev	HFET; DAY 3	POINT 10 (20" X 20" FILTER)	4.988	8.419	6.704	6.056	7.793	6.925
2.0 l chev								
2.0 l chev	NYCC; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	8.010	11.316	9.663	4.552	16.520	10.536
2.0 l chev	NYCC; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	9.294	10.812	10.053	4.978	14.801	9.890
2.0 l chev	NYCC; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	9.387	5.552	7.470	5.251	5.733	5.492
2.0 l chev	NYCC; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	4.797	9.270	7.034	5.229	10.965	8.097
2.0 l chev	NYCC; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	6.279	8.795	7.537	1.725	5.668	3.697
2.0 l chev	NYCC; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	1.982	14.294	8.138	2.557	13.609	8.083
2.0 l chev	NYCC; DAY 3	POINT 10 (20" X 20" FILTER)	6.506	4.171	5.339	5.272	3.591	4.432

VEHICLE	TEST & DAY	----- SAMPLE POINT -----	----- TOTAL PARTICULATE, MG/MILE ----- --- WITHOUT Mn --- RUN 1	RUN 2	AVG.	--- WITH Mn --- RUN 1	RUN 2	AVG.
3.8l buick	FTP; DAY 1	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	4.745	5.790	5.268	8.796	5.495	7.146
3.8l buick	FTP; DAY 1	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	4.293	5.455	4.874	8.191	5.927	7.059
3.8l buick	FTP; DAY 1	POINT 5 (1.0 SCFM; 1 FILTER)	5.640	5.396	5.518	8.350	5.386	6.868
3.8l buick	FTP; DAY 1	POINT 6 (1.7 SCFM; 1 FILTER)	4.184	4.869	4.527	6.553	4.948	5.751
3.8l buick	FTP; DAY 1	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.174	3.674	2.924	5.043	5.206	5.125
3.8l buick	FTP; DAY 1	POINT 7 (AFTER 10 MIC. CYCLADE)	3.176	5.165	4.171	4.863	6.154	5.509
3.8l buick	FTP; DAY 1	POINT 10 (20" X 20" FILTER)	4.291	3.800	4.046	6.229	3.875	5.052
3.8l buick								
3.8l buick	FTP; DAY 2	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	4.413	5.390	4.902	4.242	4.606	4.424
3.8l buick	FTP; DAY 2	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	5.295	4.286	4.791	5.096	5.908	5.502
3.8l buick	FTP; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER)	5.149	5.438	5.294	5.441	4.894	5.168
3.8l buick	FTP; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER)	4.229	4.933	4.581	4.597	3.815	4.206
3.8l buick	FTP; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	2.937	3.601	3.269	3.342	5.270	4.306
3.8l buick	FTP; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	3.569	3.743	3.656	2.574	5.179	3.877
3.8l buick	FTP; DAY 2	POINT 10 (20" X 20" FILTER)	3.802	3.968	3.885	6.016	3.407	4.712
3.8l buick								
3.8l buick	HFET; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	3.572	4.906	4.239	3.562	4.268	3.915
3.8l buick	HFET; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	3.127	3.353	3.240	3.813	3.992	3.903
3.8l buick	HFET; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	3.945	4.755	4.350	4.104	4.628	4.366
3.8l buick	HFET; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	4.242	4.821	4.532	3.596	4.137	3.867
3.8l buick	HFET; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	1.298	1.802	1.550	2.168	2.212	2.190
3.8l buick	HFET; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	0.705	1.199	0.952	1.787	2.737	2.262
3.8l buick	HFET; DAY 2	POINT 10 (20" X 20" FILTER)	3.529	3.543	3.536	2.835	2.601	2.718
3.8l buick								
3.8l buick	NYCC; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	3.610	5.580	4.595	6.765	9.070	7.918
3.8l buick	NYCC; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	5.518	6.607	6.063	10.722	9.565	10.144
3.8l buick	NYCC; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	3.274	5.098	4.186	9.795	9.593	9.694
3.8l buick	NYCC; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	2.672	5.771	4.222	6.472	8.283	7.378
3.8l buick	NYCC; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	1.645	12.030	6.838	8.410	15.238	11.824
3.8l buick	NYCC; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	6.093	14.577	10.335	10.788	19.717	15.253
3.8l buick	NYCC; DAY 2	POINT 10 (20" X 20" FILTER)	5.160	3.698	4.429	5.895	5.343	5.619
3.8l buick								
3.8l buick	FTP; DAY 3	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	2.996	6.389	4.693	4.486	7.311	5.899
3.8l buick	FTP; DAY 3	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	6.942	6.378	6.660	4.303	9.176	6.740
3.8l buick	FTP; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER)	3.527	5.788	4.658	6.791	8.514	7.653
3.8l buick	FTP; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER)	2.792	5.495	4.144	5.748	7.762	6.755
3.8l buick	FTP; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	1.838	3.571	2.705	3.749	5.784	4.767
3.8l buick	FTP; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	1.906	3.291	2.599	4.577	5.359	4.968
3.8l buick	FTP; DAY 3	POINT 10 (20" X 20" FILTER)	2.809	4.657	3.733	5.628	5.467	5.548
3.8l buick								
3.8l buick	HFET; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	2.941	5.304	4.123	3.528	5.337	4.433
3.8l buick	HFET; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	2.258	4.939	3.599	3.029	4.899	3.964
3.8l buick	HFET; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	2.972	6.363	4.668	3.098	4.615	3.857
3.8l buick	HFET; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	3.099	6.310	4.705	3.047	4.662	3.855
3.8l buick	HFET; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	0.065	2.093	1.079	0.187	3.956	2.072
3.8l buick	HFET; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	0.000	1.846	0.923	0.976	3.474	2.225
3.8l buick	HFET; DAY 3	POINT 10 (20" X 20" FILTER)	2.908	4.234	3.571	2.563	2.587	2.575
3.8l buick								
3.8l buick	NYCC; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	3.431	9.596	6.514	2.611	11.205	6.908
3.8l buick	NYCC; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	4.356	12.043	8.200	0.789	12.884	6.837
3.8l buick	NYCC; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	1.847	8.544	5.196	3.231	7.751	5.491
3.8l buick	NYCC; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	4.175	5.721	4.948	1.715	6.640	4.178
3.8l buick	NYCC; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	0.000	12.448	6.224	0.000	11.184	5.592
3.8l buick	NYCC; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	1.587	8.984	5.286	3.159	7.894	5.527
3.8l buick	NYCC; DAY 3	POINT 10 (20" X 20" FILTER)	3.896	9.268	6.582	5.066	7.482	6.274

VEHICLE	TEST & DAY	----- SAMPLE POINT -----	----- TOTAL PARTICULATE --- WITHOUT Mn --- RUN 1	RUN 2	AVG.
*2.0 l chev(c-2)	FTP; DAY 1	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	3.339	3.341	3.340
*2.0 l chev(c-2)	FTP; DAY 1	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	4.054	3.898	3.976
*2.0 l chev(c-2)	FTP; DAY 1	POINT 5 (1.0 SCFM; 1 FILTER)	4.331	4.366	4.349
*2.0 l chev(c-2)	FTP; DAY 1	POINT 6 (1.7 SCFM; 1 FILTER)	3.599	3.497	3.548
*2.0 l chev(c-2)	FTP; DAY 1	POINT 7 (AFTER 10 MIC. CYCLADE)	3.302	2.889	3.096
*2.0 l chev(c-2)	FTP; DAY 1	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.344	3.989	3.167
*2.0 l chev(c-2)	FTP; DAY 1	POINT 10 (20" X 20" FILTER)	3.651	4.297	3.974
*2.0 l chev(c-2)					
*2.0 l chev(c-2)	FTP; DAY 2	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	3.777	4.609	4.193
*2.0 l chev(c-2)	FTP; DAY 2	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	4.264	4.236	4.250
*2.0 l chev(c-2)	FTP; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER)	4.239	5.166	4.703
*2.0 l chev(c-2)	FTP; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER)	3.485	3.823	3.654
*2.0 l chev(c-2)	FTP; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	3.205	2.729	2.967
*2.0 l chev(c-2)	FTP; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.758	1.905	2.332
*2.0 l chev(c-2)	FTP; DAY 2	POINT 10 (20" X 20" FILTER)	3.383	5.146	4.265
*2.0 l chev(c-2)					
*2.0 l chev(c-2)	HFET; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	7.674	6.530	7.102
*2.0 l chev(c-2)	HFET; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	6.116	4.999	5.558
*2.0 l chev(c-2)	HFET; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	10.516	8.155	9.336
*2.0 l chev(c-2)	HFET; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	9.776	8.143	8.960
*2.0 l chev(c-2)	HFET; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	3.069	1.829	2.449
*2.0 l chev(c-2)	HFET; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	3.512	1.755	2.634
*2.0 l chev(c-2)	HFET; DAY 2	POINT 10 (20" X 20" FILTER)	12.416	11.264	11.840
*2.0 l chev(c-2)					
*2.0 l chev(c-2)	NYCC; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	22.122	23.708	22.915
*2.0 l chev(c-2)	NYCC; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	24.289	20.246	22.268
*2.0 l chev(c-2)	NYCC; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	15.918	17.415	16.667
*2.0 l chev(c-2)	NYCC; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	18.660	21.513	20.087
*2.0 l chev(c-2)	NYCC; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	8.041	11.024	9.533
*2.0 l chev(c-2)	NYCC; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	15.346	2.938	9.142
*2.0 l chev(c-2)	NYCC; DAY 2	POINT 10 (20" X 20" FILTER)	5.924	8.807	7.366
*2.0 l chev(c-2)					
*2.0 l chev(c-2)	FTP; DAY 3	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	7.482	3.842	5.662
*2.0 l chev(c-2)	FTP; DAY 3	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	5.830	4.487	5.159
*2.0 l chev(c-2)	FTP; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER)	4.030	3.889	3.960
*2.0 l chev(c-2)	FTP; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER)	3.961	3.566	3.764
*2.0 l chev(c-2)	FTP; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	2.810	3.486	3.148
*2.0 l chev(c-2)	FTP; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	3.288	3.176	3.232
*2.0 l chev(c-2)	FTP; DAY 3	POINT 10 (20" X 20" FILTER)	4.269	3.552	3.911
*2.0 l chev(c-2)					
*2.0 l chev(c-2)	HFET; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	7.821	4.524	6.173
*2.0 l chev(c-2)	HFET; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	6.396	3.181	4.789
*2.0 l chev(c-2)	HFET; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	10.358	5.963	8.161
*2.0 l chev(c-2)	HFET; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	9.888	5.873	7.881
*2.0 l chev(c-2)	HFET; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	2.825	1.483	2.154
*2.0 l chev(c-2)	HFET; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	3.031	1.088	2.060
*2.0 l chev(c-2)	HFET; DAY 3	POINT 10 (20" X 20" FILTER)	12.229	8.299	10.264
*2.0 l chev(c-2)					
*2.0 l chev(c-2)	NYCC; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	21.243	16.829	19.036
*2.0 l chev(c-2)	NYCC; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	22.793	18.046	20.420
*2.0 l chev(c-2)	NYCC; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	15.273	12.479	13.876
*2.0 l chev(c-2)	NYCC; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	18.714	16.275	17.495
*2.0 l chev(c-2)	NYCC; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	5.264	10.731	7.998
*2.0 l chev(c-2)	NYCC; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	9.504	10.061	9.783
*2.0 l chev(c-2)	NYCC; DAY 3	POINT 10 (20" X 20" FILTER)	7.045	7.511	7.278

VEHICLE	TEST & DAY	----- SAMPLE POINT -----	----- TOTAL PARTICULATE --- WITHOUT Mn --- RUN 1	RUN 2	AVG.
*3.81 buick(b-16)	FTP; DAY 1	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	5.817		5.817
*3.81 buick(b-16)	FTP; DAY 1	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	6.218		6.218
*3.81 buick(b-16)	FTP; DAY 1	POINT 5 (1.0 SCFM; 1 FILTER)	4.919		4.919
*3.81 buick(b-16)	FTP; DAY 1	POINT 6 (1.7 SCFM; 1 FILTER)	4.545		4.545
*3.81 buick(b-16)	FTP; DAY 1	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.026		4.026
*3.81 buick(b-16)	FTP; DAY 1	POINT 7 (AFTER 10 MIC. CYCLADE)	4.130		4.130
*3.81 buick(b-16)	FTP; DAY 1	POINT 10 (20" X 20" FILTER)	3.154		3.154
*3.81 buick(b-16)					
*3.81 buick(b-16)	FTP; DAY 2	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	5.699		5.699
*3.81 buick(b-16)	FTP; DAY 2	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	7.029		7.029
*3.81 buick(b-16)	FTP; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER)	5.306		5.306
*3.81 buick(b-16)	FTP; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER)	5.070		5.070
*3.81 buick(b-16)	FTP; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	4.099		4.099
*3.81 buick(b-16)	FTP; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.415		4.415
*3.81 buick(b-16)	FTP; DAY 2	POINT 10 (20" X 20" FILTER)	3.865		3.865
*3.81 buick(b-16)					
*3.81 buick(b-16)	HFET; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	4.214		4.214
*3.81 buick(b-16)	HFET; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	3.635		3.635
*3.81 buick(b-16)	HFET; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	4.233		4.233
*3.81 buick(b-16)	HFET; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	3.936		3.936
*3.81 buick(b-16)	HFET; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	2.506		2.506
*3.81 buick(b-16)	HFET; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	2.592		2.592
*3.81 buick(b-16)	HFET; DAY 2	POINT 10 (20" X 20" FILTER)	2.815		2.815
*3.81 buick(b-16)					
*3.81 buick(b-16)	NYCC; DAY 2	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	9.292		9.292
*3.81 buick(b-16)	NYCC; DAY 2	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	10.426		10.426
*3.81 buick(b-16)	NYCC; DAY 2	POINT 5 (1.0 SCFM; 1 FILTER; #2)	8.795		8.795
*3.81 buick(b-16)	NYCC; DAY 2	POINT 6 (1.7 SCFM; 1 FILTER; #2)	7.038		7.038
*3.81 buick(b-16)	NYCC; DAY 2	POINT 7 (AFTER 10 MIC. CYCLADE)	21.260		21.260
*3.81 buick(b-16)	NYCC; DAY 2	POINT 8 (AFTER 2.5 MIC. CYCLADE)	6.591		6.591
*3.81 buick(b-16)	NYCC; DAY 2	POINT 10 (20" X 20" FILTER)	7.777		7.777
*3.81 buick(b-16)					
*3.81 buick(b-16)	FTP; DAY 3	POINTS 1&2 (1.7 SCFM; 1 FILT/BAG)	8.021		8.021
*3.81 buick(b-16)	FTP; DAY 3	POINTS 3&4 (1.0 SCFM; 1 FILT/BAG)	7.975		7.975
*3.81 buick(b-16)	FTP; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER)	7.118		7.118
*3.81 buick(b-16)	FTP; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER)	6.386		6.386
*3.81 buick(b-16)	FTP; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	5.767		5.767
*3.81 buick(b-16)	FTP; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	5.463		5.463
*3.81 buick(b-16)	FTP; DAY 3	POINT 10 (20" X 20" FILTER)	4.380		4.380
*3.81 buick(b-16)					
*3.81 buick(b-16)	HFET; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	5.620		5.620
*3.81 buick(b-16)	HFET; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	5.289		5.289
*3.81 buick(b-16)	HFET; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	5.406		5.406
*3.81 buick(b-16)	HFET; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	5.133		5.133
*3.81 buick(b-16)	HFET; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	4.245		4.245
*3.81 buick(b-16)	HFET; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	4.281		4.281
*3.81 buick(b-16)	HFET; DAY 3	POINT 10 (20" X 20" FILTER)	3.542		3.542
*3.81 buick(b-16)					
*3.81 buick(b-16)	NYCC; DAY 3	POINT 1 (1.7 SCFM; 1 FILT/BAG; #1)	11.712		11.712
*3.81 buick(b-16)	NYCC; DAY 3	POINT 3 (1.0 SCFM; 1 FILT/BAG; #1)	12.440		12.440
*3.81 buick(b-16)	NYCC; DAY 3	POINT 5 (1.0 SCFM; 1 FILTER; #2)	7.966		7.966
*3.81 buick(b-16)	NYCC; DAY 3	POINT 6 (1.7 SCFM; 1 FILTER; #2)	8.750		8.750
*3.81 buick(b-16)	NYCC; DAY 3	POINT 7 (AFTER 10 MIC. CYCLADE)	15.472		15.472
*3.81 buick(b-16)	NYCC; DAY 3	POINT 8 (AFTER 2.5 MIC. CYCLADE)	16.829		16.829
*3.81 buick(b-16)	NYCC; DAY 3	POINT 10 (20" X 20" FILTER)	6.176		6.176

Data for points 5 & 8, run 1 with Mn

OBS	CARNAME	CYCLE	DAY	sampling point	PM	micrograms Mn on filt	% Mn burned on filt	weight % Mn in part.	part. weight(mg)	MPG	MILES	TOTFLOW	SCFFLOW
1	FORD	FTP	1	Point 5	12.442	5.70	7.73	1.13	0.504	17.20	11.02	9615	35.413
2	FORD	FTP	2	Point 5	7.058	5.50	7.89	1.92	0.287	18.28	11.06	9554	35.219
3	FORD	FTP	2	2.5 mic cyclade	9.463	2.90	9.36	1.70	0.171	18.28	11.06	9554	15.652
4	FORD	HFET	2	Point 5	50.077	2.80	6.93	0.15	0.906	29.40	10.24	3868	14.360
5	FORD	HFET	2	2.5 mic cyclade	41.422	1.30	7.38	0.19	0.687	29.40	10.24	3868	6.257
6	FORD	NYCC	2	Point 5	10.141	1.50	7.21	3.49	0.043	9.10	1.14	3028	16.092
7	FORD	NYCC	2	2.5 mic cyclade	9.146	0.78	12.14	4.59	0.017	9.10	1.14	3028	4.968
8	FORD	FTP	3	Point 5	8.367	6.40	9.04	1.82	0.351	18.42	11.14	9439	35.363
9	FORD	HFET	3	Point 5	48.464	2.80	7.00	0.15	0.877	0.30	10.24	3828	14.357
10	FORD	NYCC	3	Point 5	7.357	1.50	9.96	4.55	0.033	9.30	1.19	2999	11.292
11	CHEV	FTP	1	Point 5	6.439	0.05	7.45	1.85	0.270	19.17	11.03	9551	35.659
12	CHEV	FTP	2	Point 5	8.255	7.50	11.14	2.16	0.347	19.17	11.04	9529	35.635
13	CHEV	FTP	2	2.5 mic cyclade	5.997	3.20	10.70	2.86	0.112	19.17	11.04	9529	15.832
14	CHEV	HFET	2	Point 5	12.124	2.60	7.00	0.57	0.458	31.80	10.16	3878	14.431
15	CHEV	HFET	2	2.5 mic cyclade	10.883	1.30	7.95	0.72	0.181	31.80	10.16	3878	6.354
16	CHEV	NYCC	2	Point 5	10.270	1.70	12.61	3.86	0.044	0.10	1.15	3038	11.400
17	CHEV	NYCC	2	2.5 mic cyclade	16.438	0.83	13.98	2.68	0.031	0.10	1.15	3038	5.018
18	CHEV	FTP	3	Point 5	7.574	8.40	12.79	2.70	0.311	19.04	11.13	9414	33.833
19	CHEV	HFET	3	Point 5	12.025	2.60	6.73	0.57	0.460	30.70	10.25	3837	14.197
20	CHEV	NYCC	3	Point 5	7.776	1.80	13.06	5.29	0.034	9.90	1.17	3004	11.213
21	CHRY	FTP	1	Point 5	9.479	9.10	14.99	2.31	0.394	21.04	10.97	9540	35.556
22	CHRY	FTP	2	Point 5	5.948	9.50	16.40	4.01	0.237	21.12	0.11	9486	33.765
23	CHRY	FTP	2	2.5 mic cyclade	3.555	4.10	13.19	5.39	0.076	21.12	0.11	9486	18.117
24	CHRY	HFET	2	Point 5	15.352	4.20	12.18	0.73	0.577	34.10	10.16	3882	14.373
25	CHRY	HFET	2	2.5 mic cyclade	5.723	1.80	11.82	1.89	0.095	34.10	10.16	3882	6.348
26	CHRY	NYCC	2	Point 5	13.604	2.30	19.37	3.97	0.058	11.30	1.14	3022	11.383
27	CHRY	NYCC	2	2.5 mic cyclade	26.273	1.10	21.18	2.24	0.049	11.30	1.14	3022	4.979
28	CHRY	FTP	3	Point 5	6.952	0.10	16.19	3.37	0.297	21.07	11.05	9418	35.505
29	CHRY	HFET	3	Point 5	13.097	4.70	13.14	0.91	0.514	0.34	10.24	3821	14.523
30	CHRY	NYCC	3	Point 5	15.889	2.20	18.36	3.14	0.070	11.50	1.16	2990	11.367
31	2.0L	FTP	1	Point 5	4.671	8.20	16.77	5.06	0.162	26.34	11.16	9407	34.749
32	2.0L	FTP	2	Point 5	4.979	5.50	11.35	3.02	0.182	26.46	11.13	9425	34.742
33	2.0L	FTP	2	2.5 mic cyclade	2.611	1.90	8.70	3.88	0.049	26.46	11.13	9425	15.666
34	2.0L	HFET	2	Point 5	3.874	1.40	4.67	1.14	0.123	39.70	10.22	3818	14.217
35	2.0L	HFET	2	2.5 mic cyclade	1.873	0.60	4.45	1.88	0.032	39.70	10.22	3818	6.400
36	2.0L	NYCC	2	Point 5	7.898	0.01	10.31	3.57	0.028	0.14	1.16	2982	11.168
37	2.0L	NYCC	2	2.5 mic cyclade	6.712	0.46	10.54	3.54	0.013	0.14	1.16	2982	5.024
38	2.0L	FTP	3	Point 5	5.365	6.20	12.69	3.13	0.198	26.65	11.07	9116	34.317
39	2.0L	HFET	3	Point 5	5.827	1.70	5.46	0.82	0.207	39.40	10.23	3665	14.064
40	2.0L	NYCC	3	Point 5	5.251	0.84	8.33	4.42	0.019	13.60	1.14	2882	11.092
41	3.8L	FTP	1	Point 5	8.350	4.70	7.22	1.57	0.299	19.96	11.10	9236	34.599
42	3.8L	FTP	2	Point 5	5.441	5.20	8.05	2.63	0.198	19.95	11.06	9391	35.004
43	3.8L	FTP	2	2.5 mic cyclade	2.574	0.02	6.84	4.17	0.048	19.95	11.06	9391	15.857
44	3.8L	HFET	2	Point 5	4.104	1.90	5.72	1.50	0.127	36.70	10.17	3749	14.386
45	3.8L	HFET	2	2.5 mic cyclade	1.787	0.80	5.41	2.58	0.031	36.70	10.17	3749	6.402
46	3.8L	NYCC	2	Point 5	9.795	1.30	9.32	4.19	0.031	9.90	1.16	2938	11.187
47	3.8L	NYCC	2	2.5 mic cyclade	10.788	0.56	9.06	2.67	0.021	9.90	1.16	2938	4.961
48	3.8L	FTP	3	Point 5	6.791	0.05	7.77	2.12	0.236	19.84	0.11	9486	35.239
49	3.8L	HFET	3	Point 5	3.098	1.90	3.54	1.10	0.172	36.80	10.19	3790	23.518
50	3.8L	NYCC	3	Point 5	3.231	1.20	8.82	9.23	0.013	0.10	1.15	2984	11.292

Attachment 5

ETHYL CORPORATION

Inter-Office

March 21, 1991

TO: Dr. G. L. Ter Haar

FROM: I. L. Smith

SUBJECT: EPA Loaded Particulate Filters

In our particulate testing, we have not seen the high particulate weights obtained by EPA at their Motor Fuels Test Lab in Ann Arbor, Michigan. Since we do not get this particulate, we requested that EPA load some particulate filters for us to try to identify what the material is. EPA loaded 2 pairs of filters (primary and back-up filter per pair) using highway cycles. From notes (Martin Reineman of EPA) sent with the filters, and from phone conversations with Reineman, the filters were loaded using 4 highway cycles (total of about 41 miles simulated driving) per pair of filters. There are some differences.in this information and that in Reineman's notes which accompanied the filters (attached). The differences are from our phone conversations. EPA used 47 mm fluorocarbon coated fiberglass filters, per 40 CFR 86.111-82. Filter identifications used by EPA and weights of material collected were:

FILTER IDENTIFICATION	USE	WT. OF PARTICULATE
803	Primary; Set 1	0.005518 g.
804	Back-up; Set 1	0.000227 g.
805	Primary; Set 2	0.003366 g.
806	Back-up; Set 2	0.000171 g.

EPA had previously done some work on characterizing the material (Telephone contact report, December 5, 1990; D. E. Johnson, with Bruce Kolowich of EPA; attached). We repeated the qualitative work done by EPA, then did quantitative analyses. To accomplish all of this work on the samples available, the procedures described below were used.

Each filter was cut in half. The halves were given a suffix of A or B to the filter identification number used by EPA. A blank filter (obtained in a previous visit to EPA - Ann Arbor) was also cut in half, and identified as BLANK A and BLANK B.

The "A" filter sections were used for microscopy (Dr. W. D. Pitts and Dr. C. C. Devlin) and for metals analysis (Mr. D. L. Bugg and Mr. J. L. Peel). Microscopy (on a piece equivalent to 10% of the original filter) detected Ca, Ba, and Mn as was found by EPA. We did not see S which was detected by EPA. However, we did see Fe, Zn, Ti, and Cl which were not included in the elements seen by EPA. The remainder of the "A" portion was extracted with aqua regia, and the extract analyzed for the detected metals by inductively coupled plasma spectroscopy (ICP). The ICP analyses did not detect significant Ti, even though it had been seen by microscopy. While sodium analysis was desired, it was not done because of the high levels present from the fiberglass filter matrix.

The "B" filter sections were extracted with 10 mL of methylene chloride, then allowed to dry. They were then extracted with 5 mL of ion chromatography eluent (0.0022 M Na_2CO_3 - 0.0008 M $NaHCO_3$, the standard eluent used for suppressed mode anion analysis). The methylene chloride extracts were allowed to evaporate to dryness, and the residues analyzed by mass spectrometry (Dr. V. O. Brandt). The eluent solutions were analyzed by ion chromatography (Dr. P. Choudhury).

Combined results from the inductively coupled plasma and ion chromotographic analyses are given in the following table. These results are calculated on a whole filter basis. For closure purposes, results are compared with the total particulate weights given to us by EPA.

Wt. OF	FILTER 803	FILTER 804	FILTER 805	FILTER 806
Mn	0.000010	0.000001	0.000012	0.000001
Fe	0.000045	0.000008	0.000066	0.000009
Zn	0.000330	0.000044	0.000380	0.000045
Ca	0.000210	0.000025	0.000240	0.000024
Ba	0.000520	0.000065	0.000580	0.000064
Cl^-	0.003990	0.000090	0.001990	0.000090
$SO_4^=$	0.000030	<0.000010	0.000020	<0.000010
TOTAL Wt.	0.005135	0.000233	0.003288	0.000233
EPA's Wt.	0.005518	0.000227	0.003366	0.000171
CLOSURE	93 %	103%	98%	136%

$$\text{CLOSURE} = \frac{\text{(100)(Total Wt. found in our analyses)}}{\text{EPA Total particulate Wt.}}$$